# PETTINGELL-ANDREWS COMPANY

# CENTRAL STATION CATALOG

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# CENTRAL STATION

# CATALOG

SHOWING ONLY SUCH PRINCIPAL MATERIALS AS ARE PARTICULARLY SUITABLE FOR

## ORNAMENTAL STREET LIGHTING AND LINE CONSTRUCTION

ALSO

## METERS, MOTORS, TRANSFORMERS

APPARATUS AND SUPPLIES

TOGETHER WITH

VALUABLE AND USEFUL TABLES AND DATA

FULL INFORMATION GIVEN ON REQUEST FOR MATERIAL NOT SHOWN

ALL PRICES QUOTED ON REQUEST

PETTINGELL-ANDREWS COMPANY

ON THE SITE OF THE BOSTON TEA PARTY

CORNER PEARL STREET AND ATLANTIC AVENUE

BOSTON

MAIN STORE OF THE PETTINGELL-ANDREWS COMPANY
PEARL ST., ATLANTIC AVE. AND PURCHASE ST.
BOSTON

AUTOMOBILE DIVISION
100 BROOKLINE AVE.
BOSTON

Copyright 1920
by
Pettingell-Andrews Company
Boston

*"To Serve—and through the quality of Service—To Sell"*

A CONSTANT, ever ready power supply is of vastly more importance to the consumer than a cheap power rate.

In the majority of cases, the building of a transmission line is useless unless continuity of service can be maintained.

Unquestionably the largest percentage of station shut-downs are from line troubles, and the success of remotely situated developments will depend upon the reliability of their transmission lines.

With this thought ever in mind, the Pettingell-Andrews Company has endeavored to place before the Central Stations of New England a line of construction materials, every one of which has been proven in actual service by the severest of all tests—the test of time.

Each and every line of material shown in this catalog carries with it the guarantee of manufacturers who have been in business continuously for many years and who have built success upon the merit of their goods.

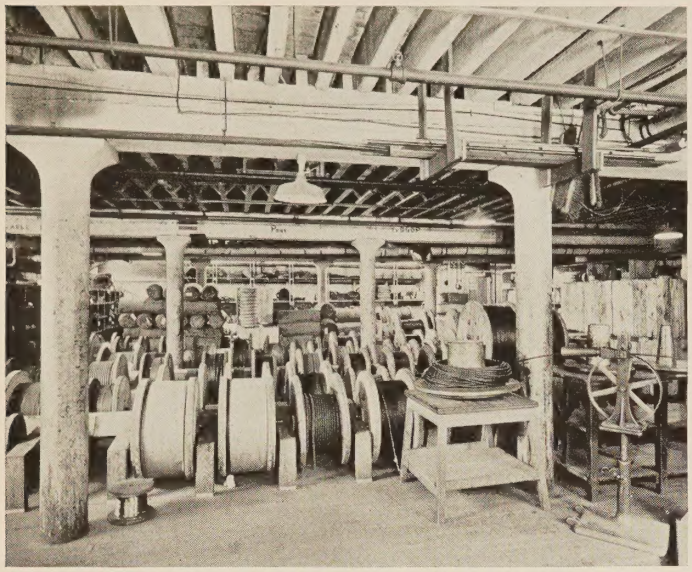
It is significant that practically all manufacturers whose goods are shown are pioneers in the manufacture of their type of product. As a result of the practical experience gained during the long period of manufacture, their products today are without question in the highest state of development.

It is logical that Pettingell-Andrews Company, being the oldest electrical jobbing house in New England, should have become associated as distributors with leading pioneers.

Through the excellence of both goods and service the Pettingell-Andrews Company, who were established in 1886, are now the largest as well as the oldest electrical jobbers in New England.

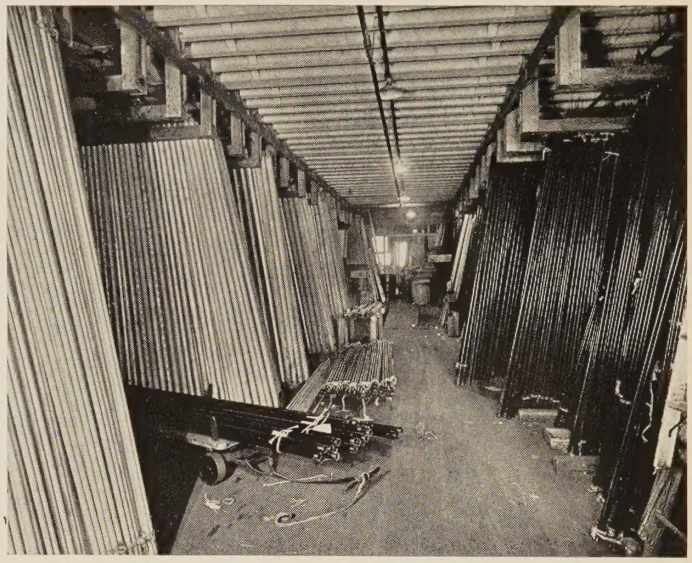
Pettingell-Andrews Company carry at all times in their warehouses the largest and most complete stock of construction materials to be found anywhere in New England. This enables the most complete and prompt shipment of goods and is a service which Central Stations will find it profitable to rely upon.

THE MARK THAT STANDS FOR
THE HEIGHT OF EXCELLENCE
IN ELECTRICAL GOODS
AND SERVICE



SECTION OF WIRE ROOM

Over 1,250,000 feet of different kinds and sizes of wire always on hand ready for quick shipment,—rubber-covered wire, armored conductor, flexible cord, weather-proofs, slow-burning, bare, insulated, iron telephone wire, galvanized strand, etc.

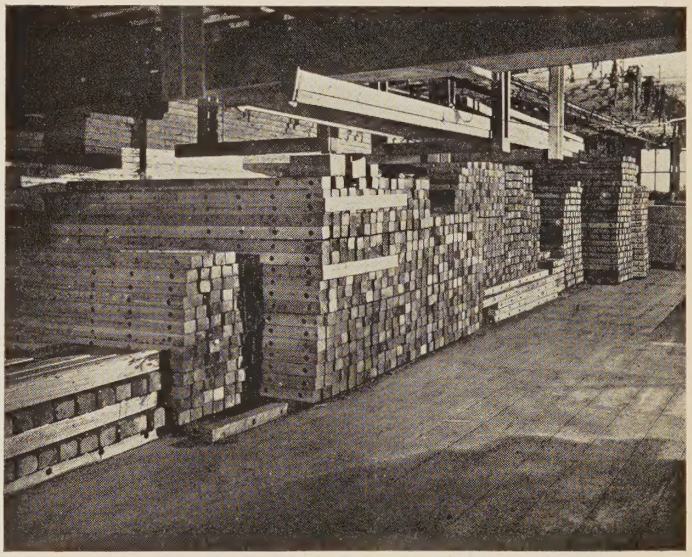


PIPE ROOM

Between 150,000 and 200,000 feet of pipe always in stock, including all sizes from ¼-inch to 4-inch, in black and galvanized, with elbows, couplings, condulets and other fittings for every size. Note method of storing all conduit on end to prevent accumulation of moisture and consequent rust.

PART OF THE POLE LINE HARDWARE STOCK

Two to five carloads constantly on hand



A CORNER OF ONE OF THE CROSS-ARM STOREROOMS

Three to ten carloads in stock at all times

This is a reproduction of the tablet marking the site of the Boston Tea Party, and is located on the PETTINGELL-ANDREWS COMPANY building, corner Pearl St. and Atlantic Ave., Boston

# *ORNAMENTAL*

# STREET LIGHTING

Realizing the importance of and the demand for *ORNAMENTAL* street lighting, the Pettingell-Andrews Company has endeavored to show a complete, dependable line of materials necessary for the proper installation of an *ORNAMENTAL* street lighting system.

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# A FEW INSTALLATIONS OF UNION METAL STANDARDS IN NEW ENGLAND

HOLYOKE, MASS.

SEASIDE PARK, BRIDGEPORT, CONN.

NEW HAVEN, CONN.

BRIDGEPORT, CONN.

FRANKLIN, N. H.

# UNION METAL STANDARDS
FOR
# *ORNAMENTAL*
## STREET LIGHTING

ORNAMENTAL lighting standards manufactured by The Union Metal Manufacturing Company, for which the Pettingell-Andrews Company are exclusive New England Distributors, possess the following points of superiority over those of any other type of manufacture.

### Points of Superiority

1. They are Handsome, Clean-Cut, Massive.
2. They have great strength and durability.
3. They are the "Safety First" Standards.
4. They insure against deaths and accidents.
5. They have scientific sectional construction.
6. They serve as shock absorbers to protect lamps and glassware.
7. They have light weight, consequently low freight and low cost of erection.
8. Sectional construction gives great flexibility in choice of design.
9. They are the modern standards — vastly superior to cast iron or concrete.
10. They are covered by a comprehensive twenty-year guarantee.

### The 20-Year Guarantee and What It Means

The Union Metal Manufacturing Company will replace, at any time within twenty years from the date of erection, any Union Metal pressed steel shaft that fails from any cause whatever (except by willful, malicious damage) for the nominal sum of Three Dollars ($3.00) each, net, F.O.B. factory, Canton, Ohio.

This insurance guarantee is printed on an envelope, one of which is attached to every steel shaft when it leaves the factory. It becomes effective and binding the day that the factory receives from the purchaser the enclosed card giving the serial number of the standard and the date installed.

This Guarantee means that these standards are insured for twenty years at the small premium of 15 cents per standard per year, this premium never coming due unless the standard meets with an accident that requires its renewal.

### The "Safety First" Feature

Union Metal Shafts cannot break when bumped into by motor vehicles or from other traffic causes.

All that can happen is to dent or bend the shaft because made of cold rolled copper bearing sheet steel, surfaces galvanized inside and out, they possess a sufficient degree of resiliency which is a vital factor of safety. And if the cast-iron base is broken the method of reinforcing with wrought-iron rods still holds the standard together.

Any shock strong enough to bend the shaft would be sufficient to break either a cast-iron or concrete standard, with its attendant danger to passersby.

Union Metal Standards obviate litigation and damage suits due to the infliction of death or personal injury to pedestrians when inferior make standards are used.

### Low Maintenance Cost

Union Metal Standards are reduced to half the weight of cast iron without slightest loss of strength and with the added advantages of massive effect combined with great attractiveness plus their "safety first" resiliency.

*They are easily shipped and handled.*

*Freight bills are cut in two.*

*Erection charges are cut in two.*

Bases can be set when the concrete foundation is built. This saves a great deal of time and the base serves as a covering and protection to the fresh concrete.

Union Metal Standards are shock and vibration absorbers. If hit a hard traffic blow which would completely shatter cast iron or concrete, their resiliency saves the standard, lamps and glassware.

The guarantee offers to replace the shaft at slight expense.

The other savings of cost in lamps, glassware, standards, freight, labor, and the defence of lawsuits, are quite obvious.

### Scientific Construction

The leadership of The Union Metal Manufacturing Company in the production of ornamental street lighting standards can be attributed largely to the scientific manner in which their standards are made.

An ornamental street lighting standard is made up of three elements: Base, shaft, and capital or head. In all standards other than Union Metal the base and shaft, that is, the bulk of the standard, is cast or molded in one piece. That necessitates a long, heavy cored casting made on its side, which frequently gives a non-uniformity of metal and always produces unsightly vertical seams extending from the base to top of standard.

Union Metal Standards are always made with base, shaft and capital or head as separate units. The bases and capitals are made of the best grade of tough gray foundry pig iron (scrap iron never used).

They are noted for relief work and sharp ornamental detail.

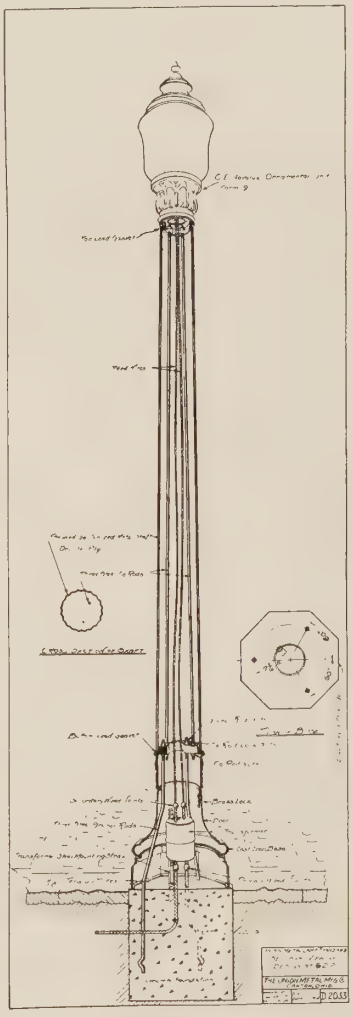
Vertical seams are eliminated. Neither are there any sand or blow holes, scales, lumps, blisters, flaws, or other imperfections.

Showing Broken Concrete Standard

Showing Broken Cast Iron Standard

## A Point That Engineers Will Appreciate

The center of gravity in a Union Metal Standard is much nearer the ground line than is possible in any other make of standard.



Sectional View of Union Metal Construction shown with GE Form 9 Novalux

## HIGHEST AWARD

### PANAMA-PACIFIC INTERNATIONAL EXPOSITION

The absolute superiority of Union Metal Standards has been recognized by the Superior Jury of Awards of The Panama-Pacific International Exposition to the extent that they were given the Highest Award.

Ask Pettingell-Andrews Company for a catalog showing the complete line of The Union Metal Manufacturing Company Standards for Ornamental Street Lighting.

Standard in Cleveland, Ohio, struck by heavy truck and knocked over at an angle of 45 degrees without falling

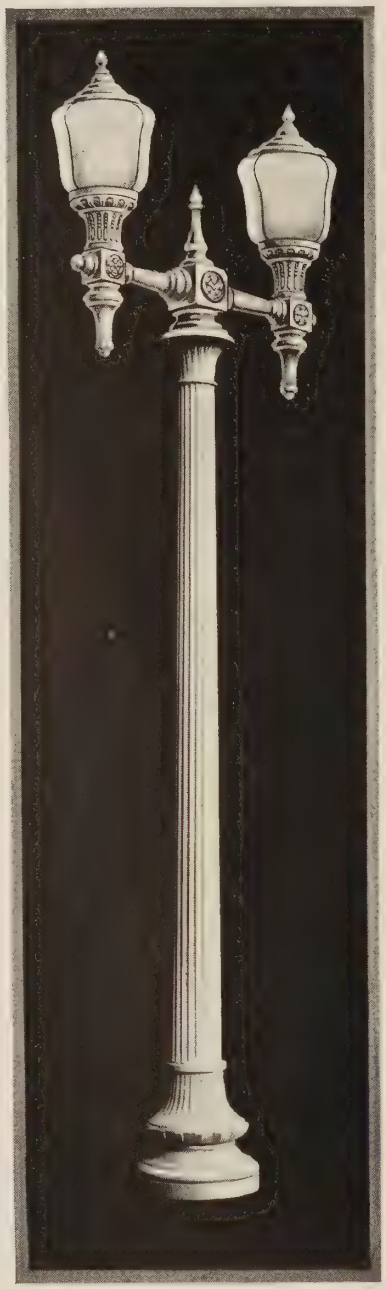
None of the glass panels nor the lamp was broken

# UNION METAL STANDARDS

Union Metal Standards in combination with General Electric Lighting Units give a lighting system in which each part is designed by engineers who have been pioneers in modern street lighting.

In their work with over one thousand cities the Union Metal designing department has developed a complete line of lighting standards which can be scientifically designed to meet any lighting conditions.

Design No. 874
with GE Form 8
Novalux Unit
as shown



Design No. 1053
with GE Form 8
Novalux Units
F Casing

Union Metal Lamp Standards, with their fluted shafts, add to the natural attractiveness of a street all day long, and at night they flood it with soft, even light which signifies a well groomed city.

Design No. 856
arranged to receive GE
Form 8 Novalux Ornamental
Unit as shown

# FOR *ORNAMENTAL* STREET LIGHTING

Anything like ornamental street lighting which adds to the traffic on a given street must therefore add to the value of the property on that street.

Lighting increases the value of residential streets by making them more desirable to live on.

A well dressed street commands attention and respect.

Design No. 792
with GE Form 9
Novalux Unit
as shown

Design No. 1082
with GE Form 13 Novalux Unit
J Casing

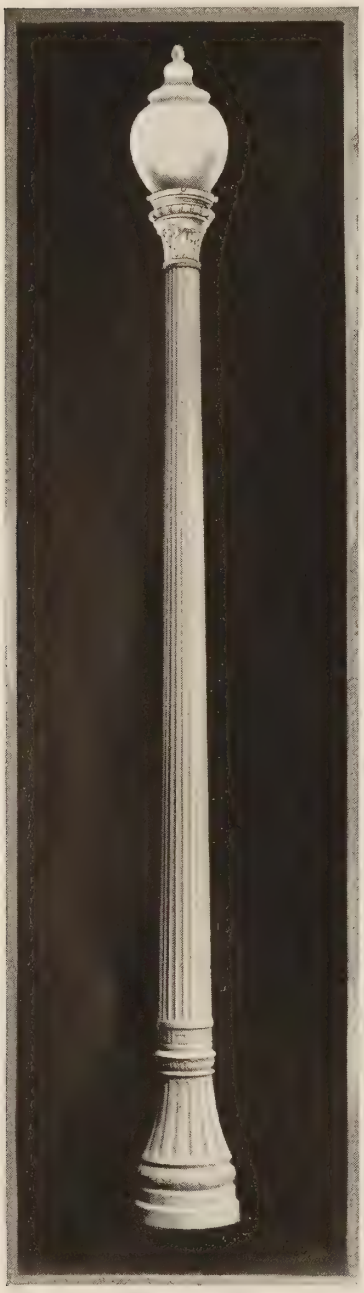
Design No. 877
with GE Novalux or
Luminous Arc

An ornamental lighting system plays an important part in the popular movement for more beautiful cities.

The use of Union Metal Lamp Standards will beautify all streets —residential as well as business.

# UNION METAL STANDARDS

Merchants on a well lighted street derive a direct tangible profit from the increased number of people passing their windows, besides the great intangible value of the good will it creates.



Design No. 1537
with GE Form 12
Novalux Unit

Design No. 608
Trolley Pole Casing used in conjunction with No. 607

Compare the Looks of This with the Ordinary Trolley Pole

Well lighted streets are naturally kept cleaner as a matter of course and will be less littered up and abused because people are proud of a good lighting system.

An ornamental lighting installation reflects credit upon the city, pleases the people, increases business, and begets a desire to improve the condition of the entire city.

Design No. 842
The "Euclid"

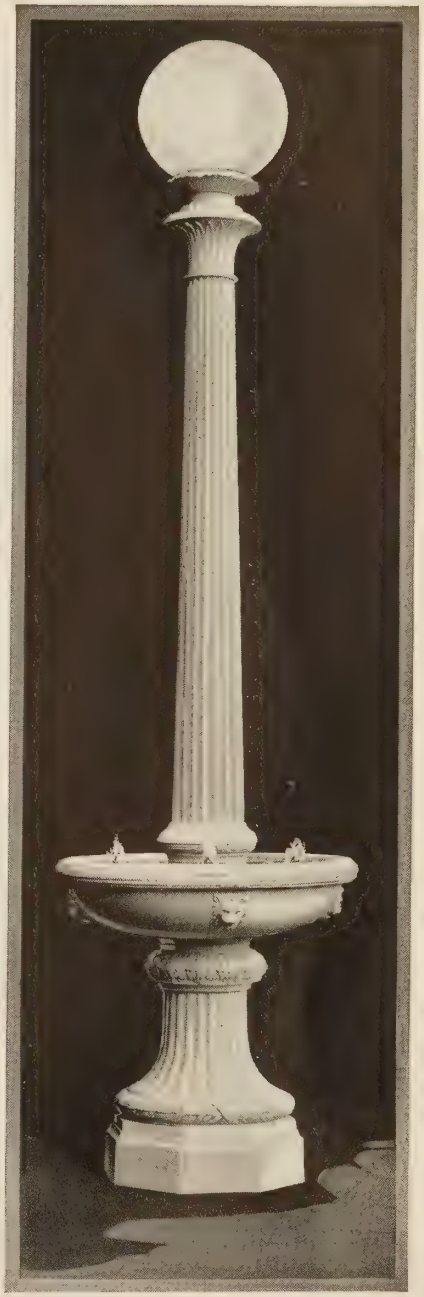
# FOR *ORNAMENTAL* STREET LIGHTING

City streets have become safe just in proportion to the extent that they have been well lighted. They are not only safer from traffic accidents but there is a great decrease in crime.

Improvement by ornamental street lighting is within the reach of the small town as well as the large city.

Design No. 684
Flower Bowl Standard
with GE Form 9
Novalux Unit

Design No. 868
Arranged to receive 3 GE Luminous Arcs
May also be used as a 2-Light Unit
The Largest and Handsomest Standard
Ever Manufactured



Design No. 557
Drinking Fountain Standard
Design No. 827
Base and Bowl Only

**Ornamental street lighting is no longer a luxury, but a necessity, as a review of its various advantages will prove.**

# NOVALUX UNITS
FOR
# *ORNAMENTAL*
## STREET LIGHTING

THE era of street lighting for strictly utilitarian purposes has passed. Street lighting, as a protective measure, for mere "path-finding," is no longer sufficient. Nowadays, the importance of the ornamental appearance of the installation is fully realized, as well as the possibilities for beautifying the streets and buildings.

The first ornamental fixtures consisted of five low candlepower incandescent lamps, each in a diffusing ball globe, mounted on ornamental standards ten to twelve feet high. With the advent of the Type C lamp, however, incandescent lamps of greater candlepower became available, and large single light standards are supplanting the cluster lights.

## Summary of Advantages

GE Novalux single light rather than cluster units are recommended for business districts because—

1. They are better looking, more graceful and lend themselves to more artistic treatment.
2. They save 10% in wattage, yield 20% more initial candlepower and save a further 20% in the distribution of light.
3. They light building fronts to a 50% higher intensity.
4. The initial cost of globes, wiring and standards is lower.
5. The maintenance saves 10% in wattage, 50% in labor and 25% in lamp renewal costs.
6. They are adaptable to all conditions of light distribution.

## FORM 8

The Form 8 unit has been designed particularly for the straight series or multiple Mazda C lamps and for the high current series lamps operated from Type IL transformers.

As this unit was not designed to contain an auto transformer, it has been possible to make it very small and compact. The casing is designed to be attached to the top of an ornamental pole having 4 in. top diameter.

## Construction of Form 8

A special porcelain socket has been designed of such size and shape that it rests on two lugs on the inside of the casing and forms the support for the receptacle and the lamp. The construction of this unit has, therefore, been reduced to the simplest possible form consisting as it does of only the casing, sockets, receptacle, lamp, globe and top ornament.

The globe seat is embodied in the casing, the globe being held by three screws. The casing used on the Form 8 unit has a simple, ornate design which will harmonize with practically any style of pole. It is furnished in two types, having the same external appearance and differing only in the method of attachment to the pole top. The "F" casing rests upon the top of the ornamental pole and is bolted in place. The "K" casing slips over the shaft and is fastened by set screws.

Straight Series Type
Cross-Section
Showing Interior

## No. 39 Diffusing Globe with Metal Canopy

Recommended for White Way lighting in small towns and villages or for supplementary ornamental lighting in large cities using the 400 or 600 c-p series or 200 and 300 watt multiple GE Edison lamps.

The diffusing globes are of such density that the light is properly diffused and no glare results from the intrinsic brilliancy of the filament. They permit enough light to be directed upward to illuminate properly the building facades. This gives an attractive daytime appearance to a street; a marked contrast to the old method of simply illuminating the streets and sidewalks and allowing the upper stories to remain in semi-darkness with a resultant tunnel-like aspect.

Inside of and at the top of the globe a reflector is placed, the function of which is to direct downward and make useful the rays of light which would otherwise be lost in the bottom of the ventilator.

In this type the canopy or top ornament is made of aluminum, with a ventilating screen between the bottom of the canopy and the top of the diffusing globe.

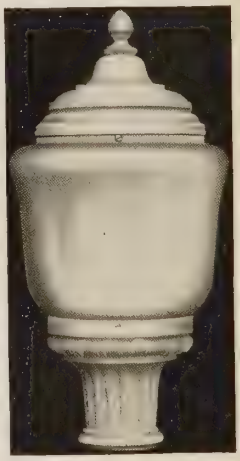


Fig. 17

## No. 39 Diffusing Globe with Glass Canopy

This combination differs only in that it has a glass canopy instead of a metal canopy.

The glass canopy is an exclusive Novalux feature which adds greatly to the beauty of the units at night. The canopy and globe are both filled with light and the appearance is very pleasing.

Fig. 17
Form 8 Unit with Glass Canopy

# FORM 9

## No. 37 Diffusing Globe and Metal Canopy

Recommended for White Way lighting using GE Edison Mazda series lamps of 600 and 1000 c-p or 400 and 500 watt multiple. This unit is almost exactly similar to the Form 8, but somewhat larger.

Fig. 18

## No. 109 Clear Rippled Globe and Dome Refractor

This unit is recommended for ornamental lighting in boulevards, parkways and beautiful residential districts. Here the conditions are somewhat different than in the business districts. All upward light is either wasted or is a source of annoyance to residents along the street.

The dome refractor eliminates all upward light.

The rippled glass assists in the diffusion and gives a live sparkling effect.

The ball globe has been used very extensively for such work but the combination of dome refractor and rippled globe gives 100% more light on the street surface than the ball globe. Assuming a satisfactory intensity of light, only one-half the number of units is required.

Rippled glass has minute protuberances and depressions on its outer surface and diffuses the light by breaking it up. It effectually prevents glare and has a very low absorption. It is more efficient than any other type of diffusing glassware.

The appearance of such a unit is entirely different than the ordinary diffusing globe. The entire globe sparkles with light and there is a suggestion of life and animation which is entirely lacking in other diffusing globes.

Fig. 20
Form 8 Unit with Three-Section Globe (No. 95) and Dome Refractor

## No. 37 Diffusing Globe and Glass Canopy

This combination differs from the above only in that it has a glass canopy instead of a metal canopy.

It is also recommended for White Way lighting.

Ask Pettingell-Andrews Company for a Catalog showing the complete line of NOVALUX Units.

Fig. 18
Form 9 Unit with Glass Canopy

For the best lighting effects with these units use

Edison Mazda Lamps

## No. 109 Clear Rippled Globe and Dome Refractor

This unit may be used for important boulevard or for secondary business streets where upward light is not required, but where an ornamental unit is preferred. It is larger than the Form 8 and should be used with 600 or 1000 c-p lamps. The dome refractor eliminates all upward light. The rippled glass assists in the diffusion and gives a live sparkling effect.

Fig. 22
Form 9 Unit with Three-Section Globe (No. 96) and Dome Refractor

## Eight Panel Diffusing Globe

This unit is recommended for the largest GE Edison Mazda lamps 750 and 1000 watt multiple or 1000 or 1500 c-p for White Way lighting in large cities. The distribution of light provides an equal amount of illumination for building fronts and for the street surface.

The globe frame and top ornament are of cast iron. The diffusing glass panels seat against felt pads attached to the ribs of the globe frame and are held in place by spring clips. A reflector is suspended above the lamp to prevent loss of light in the top ornament.

Fig. 13
Form 9 Panel Diffusing Globe Showing Upper Reflector

## Eight Panel Stippled Globe and Dome Refractor

This unit is recommended for the largest Mazda lamps, 1000 or 1500 c-p for White Way lighting in districts where it is desired to have an intense flood of light upon the streets and where the lighting of the building fronts is of secondary importance. The unit is very impressive in appearance and is without question the highest grade ornamental unit in use.

Ask Pettingell-Andrews Company for a catalog showing the complete line of NOVALUX Units.

Fig. 14
Form 9 Panel Stippled Globe Showing Dome Refractor with Upper and Lower Reflectors

## FORM 12

The Form 12 unit is the very latest idea in decorative street lighting.

### Construction of Form 12

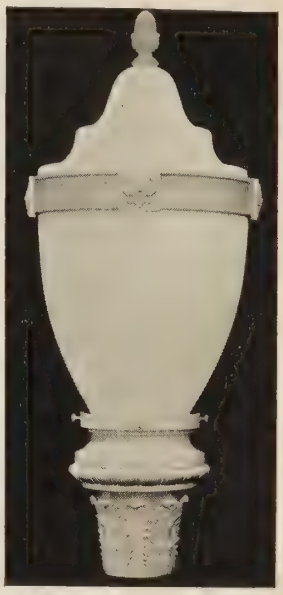
The same internal parts are used in the Form 12 units as in the Forms 8 and 9.

The casing has been designed for a slender pole having a 5 in. top diameter. The lines and ornamentation are graceful and artistic.

The contour of the globes is the result of studious effort on the part of our designing engineers, to produce a unit which would combine beauty with efficiency.

The graceful lines produce a pleasing effect and the type of glass used gives as low absorption as is consistent with perfect diffusion. The upper part of the globe is a separate glass canopy in response to the unquestioned demand for an all glass unit.

The 97 globe has the same general lines as the eight panel unit and provides a unit which is slightly less decorative than the other Form 12 types but which will find wide use in White Way lighting.



Form 12 Novalux Unit with Form M Casing, No. 104 Globe and Glass Canopy No. 1104

## FORM 13

The Form 13 unit carries the same graceful lines as the Form 12. It is particularly adapted to White Way lighting in smaller towns and villages but it should also find wide application in secondary business districts of larger cities. It is recommended for use with 400 and 600 c-p series or 300 or 400 watt multiple GE Edison Mazda lamps.

### Construction of Form 13

The same internal parts are used in the Form 13 unit as in the Form 8.

The casing is very simple in construction but exceedingly effective. It is designed for an octagonal pole but may be used with other shapes. The pole should be slender and not too ornate with a 4 in. top diameter.

The 92 globe has very small top and bottom openings. Practically all the light flux produced is projected upon the glass and diffused with a minimum of absorption. No internal reflector is necessary. Either an aluminum or a glass canopy is available.

Form 13 Novalux Unit with Octagonal Form J Cast Casing, No. 92 Globe and Metal Canopy

# NOVALUX BRACKETS AND CENTER SPAN FIXTURES

## FOR MAZDA LAMPS

## Features:

SAFETY.—All brackets and fixtures have been designed with a high safety factor so as to put safety first.

INSULATION.—The main insulator in the fixture is one massive porcelain, which has great mechanical strength and which will withstand electrical strains of 25,000 volts. Highest grade dry process porcelain, uniformly and heavily glazed, formed under high pressure and carefully dried and fired insures a homogeneous non-porous insulator free from defects.

BINDING POSTS.—Where provided, binding posts are heavy brass castings. Each post has two phosphor-bronze screws to prevent loose connections, open circuits or grounds.

DURABILITY.—Durability depends upon materials and workmanship and these factors have been given special attention.

MATERIALS.—Only the highest quality of materials is used and this together with

WORKMANSHIP of a careful and exacting nature insures great durability and

INTERCHANGEABILITY of all like parts in any given class of brackets, fixtures or their accessories.

MAINTENANCE.—Breakage is practically negligible; hence, maintenance is economical.

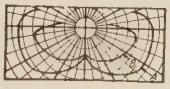
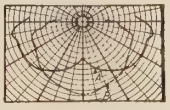
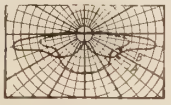
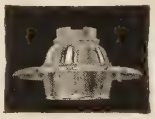
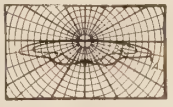
BUG PROOF.—There is no diminution of light due to a collection of insects.

APPEARANCE.—The simple lines with just sufficient ornamentation produce a most attractive appearance.

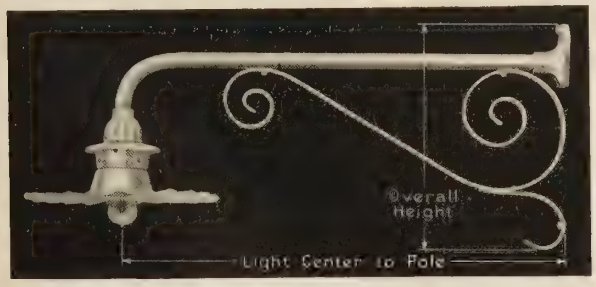
SELECTION.—The variety of designs makes it possible to select a style which will harmonize with both thoroughfare and surroundings.

## Selection of Reflectors or Refractors

(The values given in table are for average mounting of 15 to 20 feet.)

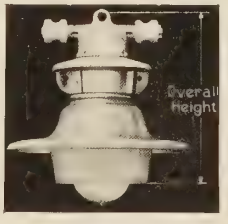
| Bracket or Fixture Equipped with | Shape of Distribution Curve | Recommended Spacing in Ft. | SERIES LAMPS Nominal C-p. | MULTIPLE LAMPS Rated Watts |
|---|---|---|---|---|
| Cat. No. 46219 20-in. radial wave reflector |  A—Series Lamp B—Multiple Lamp | 50–200 | 40<br>60<br>80<br>100 | 40<br>60 |
| Cat. No. 174270 20-in. dome radial wave reflector |  A—Series Lamp B—Multiple Lamp | 75–200 | 40<br>60<br>80<br>100<br>250<br>400 | 100<br>150<br>200 |
| Cat. No. 174273 6½-in. Holophane prismatic band refractor with holder |  A—Series Lamp B—Multiple Lamp | 50–200 | 40<br>60<br>80<br>100 | 100 |
|  Cat. No. 174276 8½-in. Holophane prismatic band refractor with holder |  A—Series Lamp B—Multiple Lamp | 100–300 | 250<br>400 | 300<br>400<br>500 |

## Dimensions of Brackets

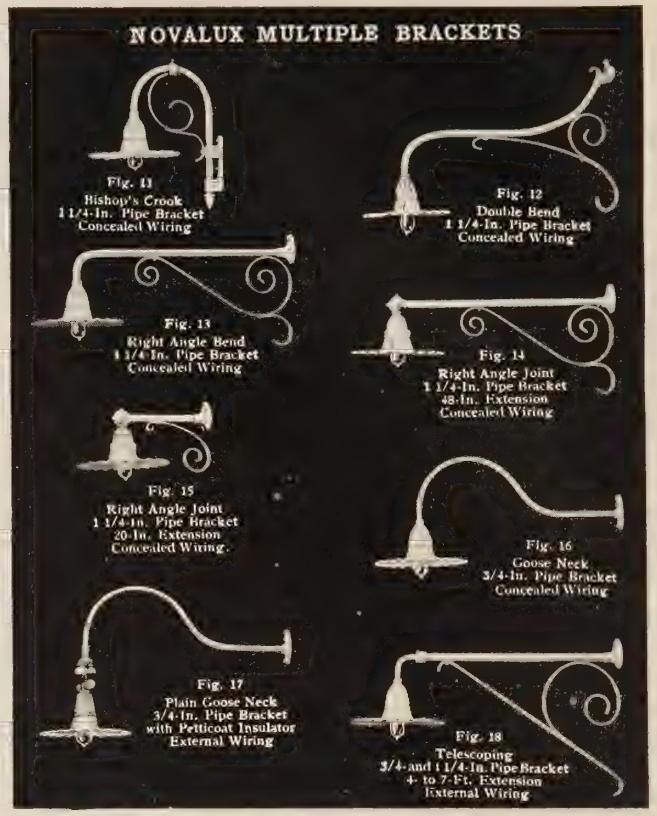



| Brackets | APPROX. DIMEN. IN IN. Light Center to Pole | Overall Height | For Illustration see Page 20 |
|---|---|---|---|
| Bishop's Crook | 20⅝ | 31½ | 1, 11 |
| Double Bend | 49¾ | 35⅜ | 2, 12 |
| Right Angle Bend | 48 | 24⅞ | 3, 13 |
| Right Angle Joint (Long) | 48 | 25⅛ | 4, 14 |
| Right Angle Joint (Short) | 20 | 16½ | 5, 15 |
| Goose Neck | 48 | 19⅝ | 6, 16 |
| Plain Goose Neck with Petticoat Insulator | 48 | 28 | 7, 17 |
| Telescoping | | | 8, 18 |

## Dimensions of Fixtures




| Fixtures | Approx. Overall Height in In. | For Illustration see Page 21 |
|---|---|---|
| SERIES | | |
| Eye Suspension with Cross Arm Insulator Hanger | 14½ | 21 |
| Strain Insulator Center Span Suspension | 8 9/16 | 22 |
| Cross Arm Suspension | 8 1/16 | 23 |
| Cross Arm Suspension with Petticoat Insulator | 13½ | 24 |
| Eye Suspension | 6 | 25 |
| MULTIPLE | | |
| Eye Suspension with Cross Arm Insulator Hanger | 16 | 28 |
| Cross Arm Suspension | 7½ | 29 |
| Cross Arm Suspension with Petticoat Insulator | 13½ | 30 |
| Eye Suspension | 7⅝ | 31 |

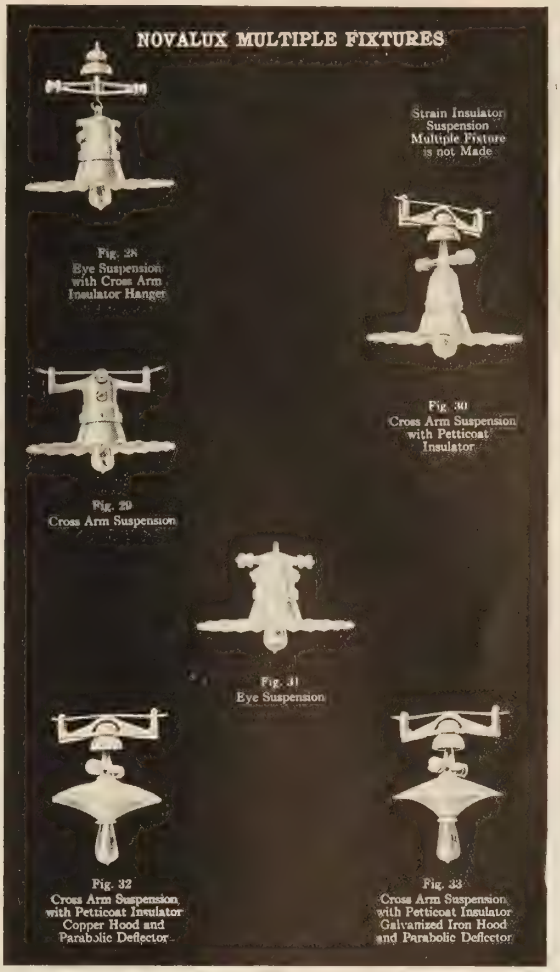


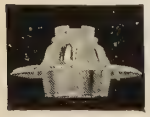

| Equipped With | FOR SERIES LAMPS C-P. | Fig. No. | Cat. No. | Approx. Ship. Wt. in Lb. per 20 Brackets |
|---|---|---|---|---|
| | | 1 | 114979 | 795 |
| | | 2 | 103156 | 885 |
| | | 3 | 105691 | 815 |
| | 40 | | | |
| | 60 | 4 | 103157 | 855 |
| | 80 | 5 | 111556 | 655 |
| | 100 | | | |
| 20-in. radial wave reflector | | 6 | 114768 | 530 |
| | | 7 | 46213 | 565 |
| | | 8 | 174311 | 935 |
| | | 1 | 174280 | 785 |
| | | 2 | 174284 | 875 |
| | 40 | 3 | 174288 | 805 |
| | 60 | | | |
| | 80 | 4 | 174292 | 845 |
| | 100 | 5 | 174300 | 645 |
| | 250 | | | |
| | 400 | 6 | 174304 | 530 |
| 20-in. dome radial wave reflector | | 7 | 174308 | 555 |
| | | 8 | 174313 | 925 |
| | | 1 | 174281 | 770 |
| | | 2 | 174285 | 860 |
| | | 3 | 174289 | 795 |
| | 40 | | | |
| | 60 | 4 | 174293 | 830 |
| | 80 | 5 | 174301 | 630 |
| | 100 | | | |
| | | 6 | 174305 | 490 |
| 6½-in. Holophane prismatic band refractor with holder | | 7 | 174309 | 545 |
| | | 8 | 174314 | 915 |
| | | 1 | 174282 | 845 |
| | | 2 | 174286 | 935 |
| | | 3 | 174290 | 870 |
| | 250 | 4 | 174294 | 905 |
| | 400 | 5 | 174302 | 695 |
| | | 6 | 174306 | 590 |
| | | 7 | 174310 | 645 |
| 8½-in. Holophane prismatic band refractor with holder | | 8 | 174315 | 980 |

Standard finish, black japan; galvanized iron finish can be furnished at an increased price.

| Equipped With | FOR MULTIPLE LAMPS Watts | Fig. No. | Cat. No. | Approx. Ship. Wt. in Lb. per 20 Brackets |
|---|---|---|---|---|
| | | 11 | 161339 | 625 |
| | | 12 | 152822 | 800 |
| | | 13 | 161350 | 730 |
| | 40 | 14 | 161356 | 730 |
| | 60 | 15 | 161362 | 530 |
| 20-in. radial wave reflector | | 16 | 152833 | 440 |
| | | 17 | 125323 | 565 |
| | | 18 | 174368 | 800 |
| | | 11 | 174337 | 615 |
| | | 12 | 174341 | 785 |
| | | 13 | 174345 | 720 |
| | 100 | 14 | 174349 | 720 |
| | 150 | 15 | 174357 | 520 |
| | 200 | | | |
| 20-in. dome radial wave reflector | | 16 | 174365 | 430 |
| | | 17 | 174361 | 555 |
| | | 18 | 174370 | 790 |
| | | 11 | 174338 | 595 |
| | | 12 | 174342 | 765 |
| | | 13 | 174346 | 695 |
| | 100 | 14 | 174350 | 700 |
| | | 15 | 174358 | 500 |
| | | 16 | 174366 | 420 |
| 6½-in. Holophane prismatic band refractor with holder | | 17 | 174362 | 545 |
| | | 18 | 174371 | 720 |
| | | 11 | 174339 | 695 |
| | | 12 | 174343 | 865 |
| | | 13 | 174347 | 795 |
| | 300 | 14 | 174351 | 800 |
| | 400 | 15 | 174359 | 600 |
| | 500 | | | |
| | | 16 | 174367 | 520 |
| | | 17 | 174363 | 645 |
| 8½-in. Holophane prismatic band refractor with holder | | 18 | 174372 | 820 |

Standard finish, black japan; galvanized iron finish can be furnished at an increased price.




| Equipped With | FOR SERIES LAMPS C-P. | Fig. No. | Cat. No. | Approx. Ship. Wt. in Lb. per 20 Fixtures |
|---|---|---|---|---|
| 20-in. radial wave reflector | 40 | 21 | *74810 | 510 |
| | 60 | 22 | 125359 | 425 |
| | 80 | 23 | 103158 | 430 |
| | 100 | 24 | 49055 | 465 |
| | | 25 | 103159 | 400 |
| 20-in. dome radial wave reflector | 40 | 21 | *174317 | 500 |
| | 60 | 22 | 174321 | 415 |
| | 80 | 23 | 174325 | 420 |
| | 100 | 24 | 174329 | 455 |
| | 250 | 25 | 174333 | 390 |
| | 400 | | | |
| 6½-in. Holophane prismatic band refractor with holder | 40 | 21 | *174318 | 485 |
| | 60 | 22 | 174322 | 400 |
| | 80 | 23 | 174326 | 405 |
| | 100 | 24 | 174330 | 440 |
| | | 25 | 174334 | 375 |
|  8½-in. Holophane prismatic band refractor with holder | 250 | 21 | *174319 | 540 |
| | 400 | 22 | 174323 | 500 |
| | | 23 | 174327 | 485 |
| | | 24 | 174331 | 520 |
| | | 25 | 174335 | 475 |

* For omission of hanger, a reduction in price is made.

Standard finish, black japan; galvanized iron finish can be furnished at an increased price.

| Equipped With | FOR MULTIPLE LAMPS Watts | Fig. No. | Cat. No. | Approx. Ship Wt. in Lb. per 20 Fixtures |
|---|---|---|---|---|
| 20-in. radial wave reflector | 40 | 28 | *161383 | 560 |
| | 60 | 29 | 161389 | 440 |
| | | 30 | 125324 | 465 |
| | | 31 | 161395 | 415 |
| 20-in. dome radial wave reflector | 100 | 28 | *174374 | 550 |
| | 150 | 29 | 174386 | 430 |
| | 200 | 30 | 174382 | 455 |
| | | 31 | 174378 | 405 |
| 6½-in. Holophane prismatic band refractor with holder | 100 | 28 | *174375 | 535 |
| | | 29 | 174387 | 395 |
| | | 30 | 174383 | 420 |
| | | 31 | 174379 | 390 |
| 8½-in. Holophane prismatic band refractor with holder | 300 | 28 | *174376 | 635 |
| | 400 | 29 | 174388 | 515 |
| | 500 | 30 | 174384 | 540 |
| | | 31 | 174380 | 490 |

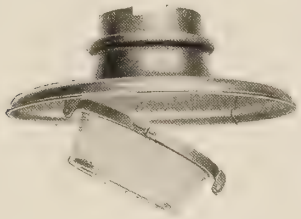
* For omission of hanger, a reduction in price is made.

Standard finish, black japan; galvanized iron finish can be furnished at an increased price.

## Reflectors and Refractors

CAT. NO. 46219—20-IN. RADIAL WAVE REFLECTOR
For 40, 60, 80 and 100 c-p. Series and 40 and 60 Watt Multiple Lamps
Ship. Wt. per 20—131 Lb.

CAT. NO. 174270—20-IN. DOME RADIAL WAVE REFLECTOR
For 40, 60, 80, 100, 250 and 400 c-p. Series and 100, 150 and 200 Watt Multiple Lamps
Ship. Wt. per 20—145 Lb.



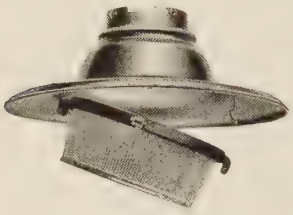
Open

Closed

CAT. NO. 174273—6½-IN. HOLOPHANE PRISMATIC BAND REFRACTOR WITH CANOPY AND HOLDER. For 40, 60, 80 and 100 c-p. Series and 100 Watt Multiple Lamps.

Ship. Wt. per 10—65 Lb.

Consists of: Cat. No. 174272 Holder and Cat. No. 174271 Refractor.



Open

Closed

CAT. NO. 174276—8½-IN. HOLOPHANE PRISMATIC BAND REFRACTOR WITH CANOPY AND HOLDER. For 250 and 400 c-p. Series and 300, 400 and 500 Watt Multiple Lamps.

Ship. Wt. per 10—80 Lb.

Consists of: Cat. No. 174275 Holder and Cat. No. 174274 Refractor.

### RADIAL WAVE REFLECTOR (Cat. No. 46219)

FINISH.—Heavily enameled on upper and lower surfaces with highly-glazed reflecting surface.

DISTRIBUTION.—The waves serve to make the reflected light of uniform intensity on all sides of the lamp. The reflector gives a fair amount of light at the higher angles with more light toward the vertical.

### DOME RADIAL WAVE REFLECTOR (Cat. No. 174270)

FINISH.—Same as for the Radial Wave Reflector.

DISTRIBUTION.—The waves equalize the light on all sides of the lamp but the maximum light is reflected at a 10-degree angle and thus promotes uniform intensities from lamp to lamp.

CONSTRUCTION.—A large handhole enables the removal of both socket and lamp as a unit. The dome not only adds to appearance, but serves to reflect the upward rays so that the only light lost is that cut off by the base of the lamp. The reflector has a rolled edge which prevents the splitting of the enamel or the rusting of the reflector.

### BAND REFRACTOR (Cat. Nos. 174273 and 174276)

FINISH.—Clear glass, smooth on outer and inner surfaces.

DISTRIBUTION.—The refracting prisms thoroughly diffuse the light and direct both upward and downward light to the 10-degree angle. The direct downward light is unobstructed and this affords ample illumination beneath the lamp. The refractor makes a beautiful appearance.

CONSTRUCTION.—The refractor consists of two clear glass bands one of which fits snugly within the other in which position the joints are sealed. The outer surface of the inner band has horizontal prisms which direct the light to an angle of 10 degrees below the horizontal. The inner surface of the outer band has vertical prisms which spread the light transversely. Liberal hand room in the dome interior enables the removal of lamp and socket as a unit. By releasing the automatic spring latch, the refractor holder, which is hinged to the spun dome, can be lowered. Cleaning is thus facilitated. The small size and the shape of the canopy prevent the collection of snow and ice upon it and also make it a smaller mark for malicious breakage.

## Sockets and Receptacles

Fig. 35

Fig. 36

Fig. 37

Fig. 38

Fig. 39

Fig. 40

Fig. 41

Fig. 42

Fig. 43

Fig. 44

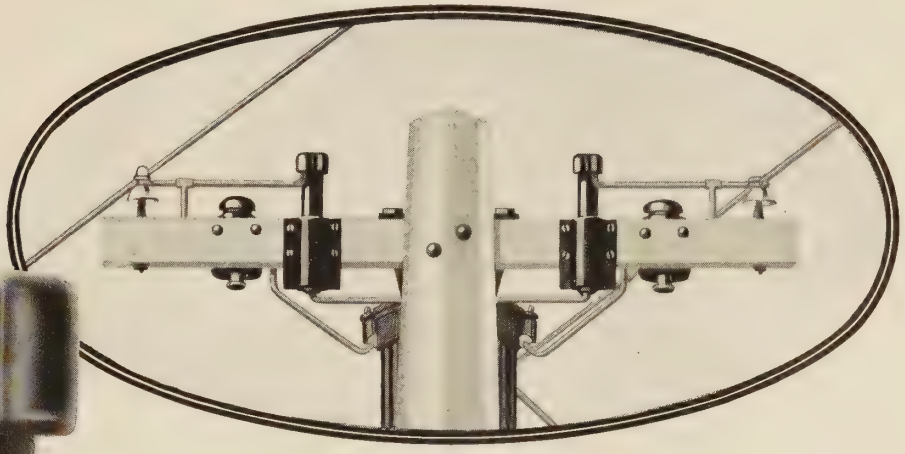
| Cat. No. | Fig. No. | Descriptive | Ship. Wt. in Lb. per 100 |
|---|---|---|---|
| 25708 | .. | Porcelain series, socket and receptacle, complete, including iron yoke, Cat. No. 25714, for use with Mogul screw base lamps | 200 |
| 25711 | 35 | Porcelain series socket only, for Mogul screw base lamps | 112 |
| 177143 | 36 | Porcelain receptacle with clips | 100 |
| 25720 | 37 | Porcelain series socket only, for medium screw base lamps | 46 |
| †156722 | 38 | Skeleton multiple socket for Mogul screw base lamps | 52 |
| 129804 | 39 | Porcelain multiple socket, for Mogul screw base lamps | 112 |
| 129803 | 40 | Porcelain multiple socket, for medium screw base lamps | 112 |
| *159377 | 41 | Porcelain multiple socket with ½-in. pipe tap, for Mogul screw base lamps with plunger spring center contact | 330 |
| †GE427 | 42 | Porcelain multiple socket with yoke for ½-in. pipe, for medium screw base lamps | 80 |
| 25712 | 43 | Porcelain receptacle with clip and iron yoke. This is Cat. No. 25708 less Cat. No. 25711 | 103 |
| 25713 | .. | Porcelain receptacle with clips only | 54 |
| 25714 | .. | Iron yoke (⅞-in.—18 thread) with two screws Cat. No. 10252. Used in Cat. No. 25712 | 50 |
| ‡46627 | 44 | Keyless receptacle | 30 |
| 65951 | .. | Aluminum disk film cutout. Tested for 110 volts; probable limit of breakdown 250 to 450 volts | ¼ |
| §147969 | .. | Lead disk film cutout. Tested for 70 volts; probable limit of breakdown, 70 to 250 volts | ¼ |

* Class B—Standard package 50.
† Class B—Standard package 100.
‡ Class B—Standard package 250.
§ Designed for use with lamps operated from SL transformers.

NOTE.—With each shipment of 12 or less of the above series sockets, a package of 15 disk film cutouts, Cat. No. 65951, is included.

# COMPRESSION CHAMBER MULTIGAP LIGHTNING ARRESTERS

OUTDOOR SERVICE — UP TO 15,000 VOLTS



CONTINUITY of service is largely dependent upon strong mechanical and electrical transformer construction and adequate lightning protection.

Every time lightning damages a transformer or causes its fuses to blow, thereby interrupting service, there is being created that most destructive of feelings, — ill-will — which eventually strikes your bank account.

Nothing is more unprofitable than a dissatisfied public, and nothing more disturbing than constant complaints because of poor service.

*GE transformers* provide transformer strength; *GE lightning arresters* furnish lightning protection.

*Fuse blowing can be greatly reduced and injury to transformers practically eliminated* by installing efficient lightning arresters on each transformer pole. The farther away the arrester is from the transformer the greater will be the potential strain on the transformer during lightning disturbances. With the lightning arrester located one pole away, the potential strain on the transformer under some conditions is *double* what it would be with the arrester installed on the same pole.

*Installation of arresters and transformers, at the same time on the same pole, results in economy in installation and maintenance.*

## Features

*Efficient*—Because the multigap principle of lightning arrester design is carried out to the highest scientific degree. Proved to be efficient by the experience of some of the largest operating companies.

*Light*—Because the arrester has no wooden case, which not only requires entrance bushings but also has to be made larger than is required for the support of the elements and their protection against the weather, on account of the necessity of allowing proper clearance.

*Compact*—Because the elements are tightly enclosed in porcelain, the amount and quality of which are carefully judged so that no material is used in excess of that consistent with good operation.

*Weatherproof*—Because the porcelain is impervious to water and the joints are sealed in such a way that water can by no possibility enter the arrester.

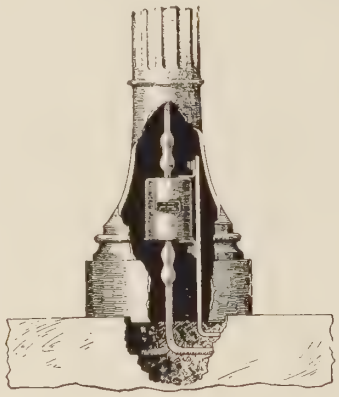
*Fireproof*—Because nothing combustible is used in its construction.

*Require No Inspection after Installation*—Because the arresters are weatherproof and fireproof, inspection is unnecessary. As long as the arrester is intact it is in operating condition.

# TYPE IL SERIES TRANSFORMERS

## FOR STREET LIGHTING SERVICE

THE high efficiency of the 15- and 20-amp. Mazda series lamps has made them very popular for street illumination. Individual auto-transformers have been commonly employed to operate them from standard 6.6- or 7.5-amp. constant current series circuits. Recently, however, due to a number of inherent advantages, there has been a considerable demand for a small series transformer to operate a single lamp by stepping up the line current to the higher current required by the lamp.



These transformers are divided into two general types, one being insulated for operation on secondary circuits up to a maximum of 5500 volts and the other up to a maximum of 10,500 volts. The high-voltage (10,500 volts) type has the casing filled with compound. The low-voltage (5500 volts) type is not filled with compound unless specially requested.

The compound is an additional protection against moisture reaching the windings, and the transformers having this feature should be recommended when installed where excessive moisture conditions exist. When transformers that are not compound filled are used in places where moisture conditions are severe, extreme care should be taken in wiping the joints in order to insure a watertight joint between cable and transformer. To eliminate the necessity for wiped joints, we can furnish detachable couplings for the primary leads.

The subway type transformers are used for Mazda ornamental street lighting. The subway type transformers are generally mounted in the base of ornamental posts, in a manhole or subway, or in any manner that local conditions may require. In fact, when convenience demands, the insulation is so perfect and the construction so watertight and dampproof that they may actually be buried in the ground. When this is done, however, it is recommended that they be embedded in tar. Figs. 6, 7, 8 and 9 show a few of the various methods of mounting.

Fig. 1
Subway Type

They are built in capacities that take care of the 400, 600 and 1000 c-p. series Mazda lamps. The standard primary windings are for 6.6 or 7.5 amperes, and the standard secondary winding is for 15 amperes (400 c-p.) or 20 amperes (600 and 1000 c-p.). Special primary windings for any commercial circuits can, however, be supplied.

### Construction

These transformers are entirely enclosed in a steel casing and are absolutely waterproof. All leads on the subway type transformers are brought out through galvanized iron wiping sleeves so that the lead sheath of the underground cable can be readily wiped on. For aerial use, the leads are brought out through porcelain bushings.

Each primary lead is brought out separately and a space of approximately 2½ inches is left between the primary wiping sleeves. This makes the most convenient arrangement for connecting on primary leads, where, in the majority of cases, a single conductor cable is employed.

While the standard arrangement of leads is to have the two primary leads brought out at one end of the transformer and the secondary leads at the other end, the internal arrangement is such that transformers can readily be built to meet any special requirement in the bringing out of leads. It is possible to furnish these transformers with the primary leads brought out at the two ends of the transformer and the secondary leads brought out at whichever end is most convenient. This makes a very convenient arrangement when it is desired to place the transformer in the ground near the base of the pole, as has been suggested. The casing for these transformers is made of steel and has a black weatherproof finish.

To eliminate the necessity for wiped joints we can furnish transformers equipped with detachable couplings for the primary leads. To attach these couplings it is necessary only to peel back the lead sheath and solder the bushing to the sheath. The resultant joint is easily made and is watertight.

Fig. 3
Wiped Joints

Fig. 4
Detachable Couplings

Type IL Series Transformers—Subway Type

Electrically, these transformers are designed to meet the most exacting requirements of this class of service and they

will run continuously with the secondary open-circuited, thereby avoiding any possibility of trouble in case a lamp is broken or burns out.

## Regulation

When lamp wattage varies between 8 per cent above and 20 per cent below normal, secondary current will not vary more than 1.0 per cent with normal primary current and frequency.

## Protection

Primary current can go 75 per cent above normal without increasing secondary current over 45 per cent.

All transformers insulated for 10,500-volt circuits take an insulation test of 22,000 volts for one minute between primary and all parts. All transformers are given an insulation test of 1500 volts from secondary windings to metal parts. The transformers insulated for 5500-volt circuits are given a test of 12,000 volts for one minute between primary and all parts. These tests are in accordance with the latest rulings of the A. I. E. E.

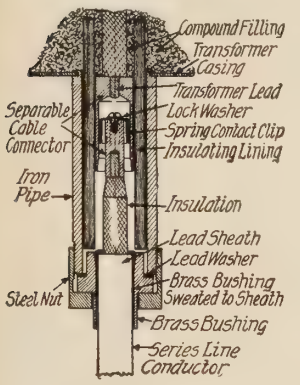



Fig. 5
Sectional View of Detachable Coupling for Primary Lead

## Advantages

A few of the advantages of these individual-lamp series transformers are as follows:

High efficiency series lamps can be used where high potential is impracticable.

No film cutout is required since each lamp is independent of the others in the circuit. In case of an accident to one or more, the remainder of the lamps on the circuit burn without interruption.

They protect the lamps from surges in the line.

They are a valuable adjunct to "Safety First" in ornamental street lighting, because they insulate the pole and lamp from the high tension series circuit and permit the use of high efficiency series lamps in business districts where ordinances prohibit high tension wires above the street surface.

For use with pendant units, the transformers can be mounted on the cross-arms of the poles.

They save the expense of high-voltage conductors, heavy insulation and high tension cutouts, a saving which materially assists in liquidating the difference between the first cost of auto-transformers and series transformers, the latter being naturally somewhat higher priced.

Furthermore this low voltage eliminates the "75 per cent of all line troubles" which occur between the pole and the lamp.

## Methods of Mounting

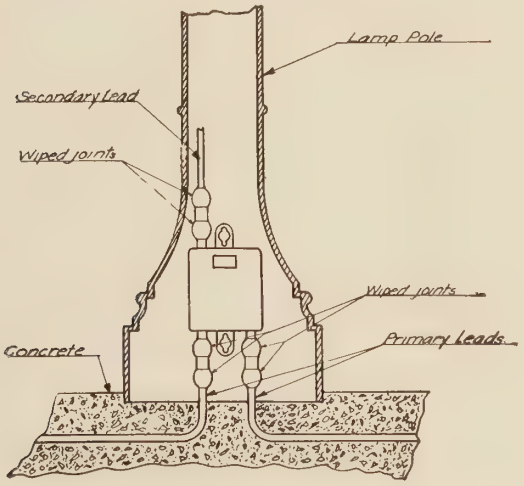



Fig. 6
Series Transformer Mounted in Pole on Lugs Cast in Base (Front View)

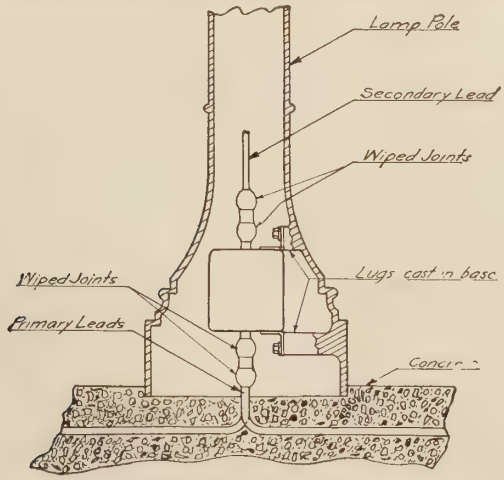



Fig. 7
Series Transformer Mounted in Pole on Lugs Cast in Base (Side View)

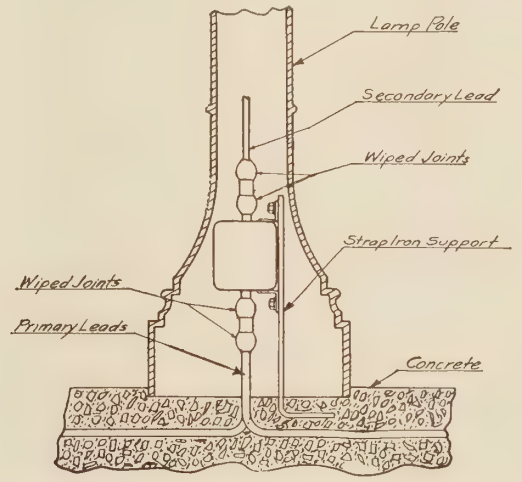



Fig. 8
Series Transformer Mounted in Base of Pole on Strap Iron Support Embedded in Concrete

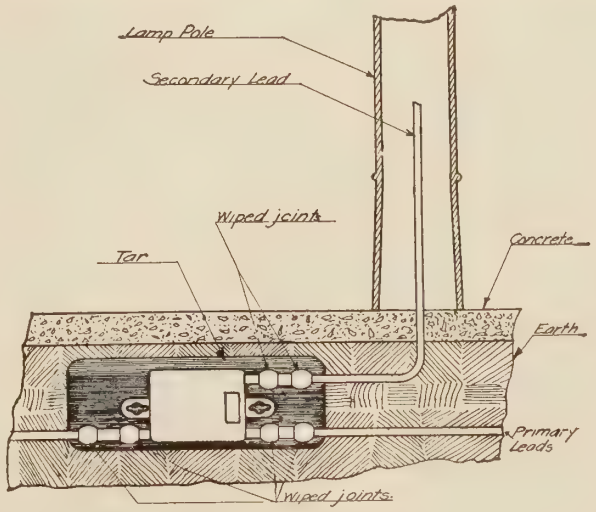
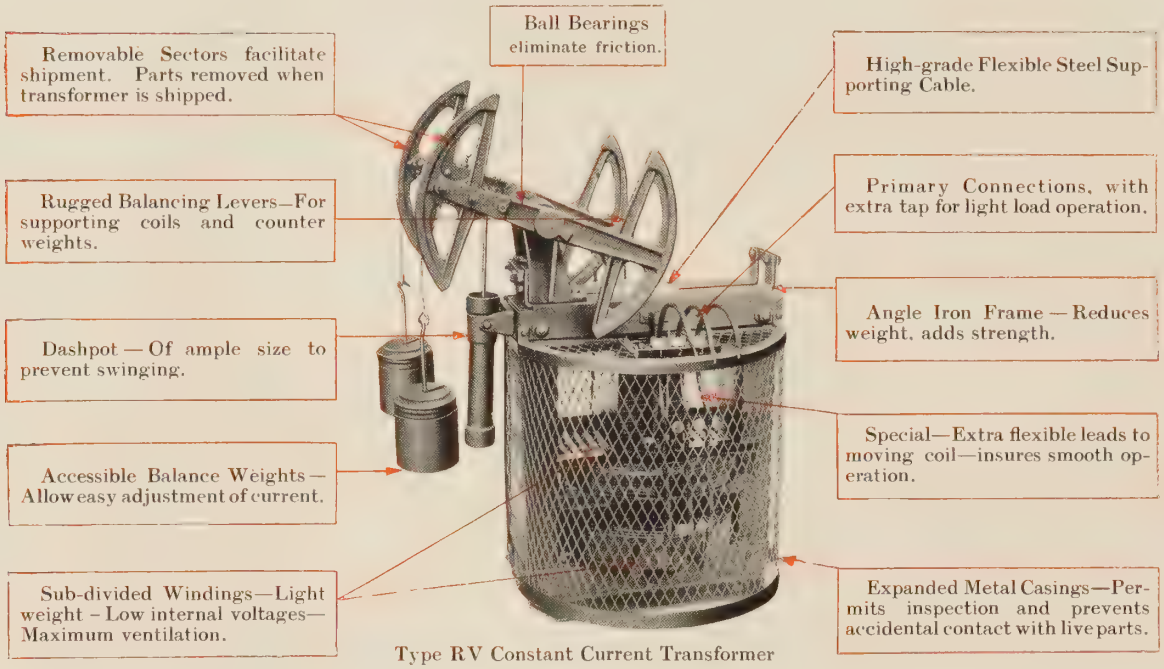



Fig. 9
Series Transformer Buried in Ground

# CONSTANT CURRENT TRANSFORMER

## TYPE RV

Standard, 60 Cycles, 2300 Volts, Primary; 6.6 or 7.5 Amperes Secondary.
Can be furnished for any Primary Voltage up to 5000 Volts.
Any Frequency or any Secondary Current.
For Primary Voltage over 5000 Volts, Specify Type RJ.


Ball Bearings eliminate friction.
Removable Sectors facilitate shipment. Parts removed when transformer is shipped.
High-grade Flexible Steel Supporting Cable.
Rugged Balancing Levers—For supporting coils and counter weights.
Primary Connections, with extra tap for light load operation.
Dashpot — Of ample size to prevent swinging.
Angle Iron Frame — Reduces weight, adds strength.
Accessible Balance Weights — Allow easy adjustment of current.
Special—Extra flexible leads to moving coil—insures smooth operation.
Sub-divided Windings—Light weight – Low internal voltages—Maximum ventilation.
Expanded Metal Casings—Permits inspection and prevents accidental contact with live parts.

Type RV Constant Current Transformer

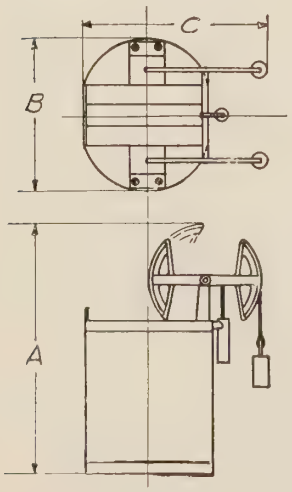
## The Constant Current Transformer is a single piece of apparatus which:

Insulates load circuit from supply circuit.

Requires no skilled labor for operating or adjusting.

Delivers the correct current to load circuit under *all* conditions of supply and load without change of adjustment.

Protects lamps against variations of supply voltage or frequency, and against changes of load due to grounds or short circuits.



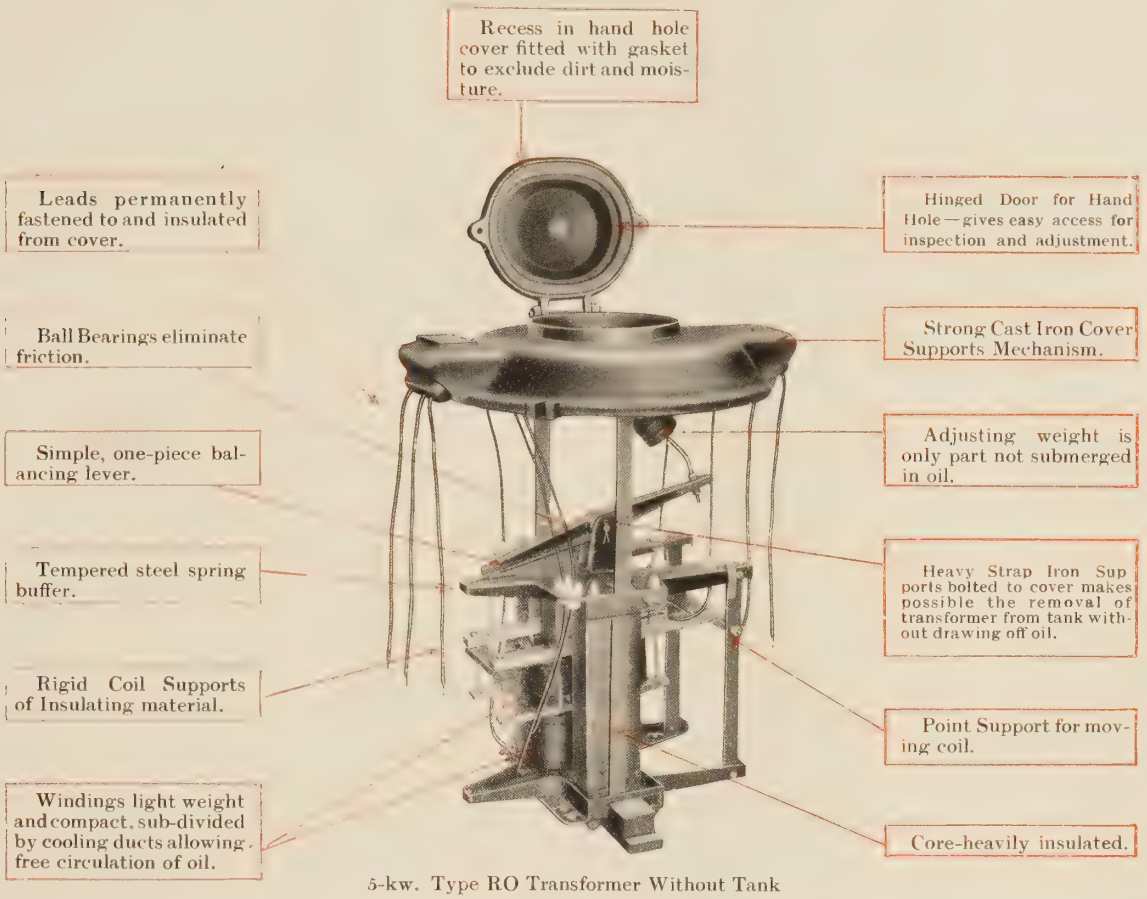

| Cat. No. | Kw. | Amps. | DIMENSIONS IN INCHES | | | APPROX. WT. IN LB. | |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | Net | Ship. |
| 197089 | 5 | 6.6 | 34 | 17 | 23 | 300 | 500 |
| 197091 | 10 | 6.6 | 37 | 20 | 25 | 475 | 650 |
| 197093 | 15 | 6.6 | 40 | 23 | 28 | 650 | 850 |
| 197095 | 20 | 6.6 | 44 | 25 | 30 | 800 | 1000 |
| 197097 | 25 | 6.6 | 48 | 27 | 34 | 1050 | 1450 |
| 197099 | 30 | 6.6 | 53 | 28 | 38 | 1250 | 1600 |

# CONSTANT CURRENT TRANSFORMER

## TYPE RO

Standard, 60 Cycles, 2000/2300 Volts, Primary; 6.6 or 7.5 Amperes, Secondary

Can be furnished for any Primary Voltage, Frequency or Secondary Current


Recess in hand hole cover fitted with gasket to exclude dirt and moisture.
Leads permanently fastened to and insulated from cover.
Hinged Door for Hand Hole—gives easy access for inspection and adjustment.
Ball Bearings eliminate friction.
Strong Cast Iron Cover Supports Mechanism.
Simple, one-piece balancing lever.
Adjusting weight is only part not submerged in oil.
Tempered steel spring buffer.
Heavy Strap Iron Supports bolted to cover makes possible the removal of transformer from tank without drawing off oil.
Rigid Coil Supports of Insulating material.
Point Support for moving coil.
Windings light weight and compact, sub-divided by cooling ducts allowing free circulation of oil.
Core-heavily insulated.

5-kw. Type RO Transformer Without Tank

Will maintain constant current within 1 per cent. of normal from full load to short circuit.

An outdoor weatherproof unit, oil cooled, designed for pole mounting, but may also be used in the central station or sub-station.

Requires no attendant or control panel.

Regulation entirely automatic and instantaneous—no taps or adjustments.

The first and only outdoor transformer that automatically maintains constant current under all conditions.

5-kw. Type RO Transformer

### WEIGHTS—TYPE RO TRANSFORMERS

| Cat. No. | Kw. | Amps. | APPROX. WT. IN LB. Gals. Oil | Wt. Oil | Net Less Oil | Ship. Less Oil | EFFICIENCIES Full Load | ¾ Load | ½ Load | ¼ Load |
|---|---|---|---|---|---|---|---|---|---|---|
| 197065 | 1 | 6.6 | 28 | 200 | 275 | 425 | 91.5 | 89 5 | 85.0 | 73.0 |
| 197066 | 2 | 6.6 | 32 | 230 | 320 | 520 | 93.0 | 91 0 | 87.0 | 77.0 |
| 197067 | 3 | 6.6 | 32 | 230 | 365 | 560 | 93.5 | 91.5 | 88.0 | 78.5 |
| 197068 | 5 | 6.6 | 40 | 290 | 420 | 630 | 94.0 | 92 1 | 89.0 | 80.0 |
| 197069 | 7.5 | 6.6 | 40 | 290 | 450 | 660 | 94.5 | 92.7 | 90.0 | 82.0 |
| 197070 | 10 | 6 6 | 40 | 290 | 500 | 710 | 95.0 | 93.5 | 91.0 | 83.5 |
| 219573 | 15 | 6.6 | 75 | 540 | 900 | 1300 | 94 5 | 93.0 | 90.0 | 81.0 |
| 219575 | 20 | 6.6 | 85 | 610 | 1100 | 1500 | 94.6 | 93.1 | 90.0 | 81.0 |

Primary Power Factors: Full load 70, ¾ load 51, ½ load 36, and ¼ load 20.

20-kw. Type RO Transformer

OKONITE
TRADE MARK
REG. U.S. PATENT OFFICE.

## Over 40 Years the Standard for Rubber Insulation

Manufactured by

## THE OKONITE COMPANY

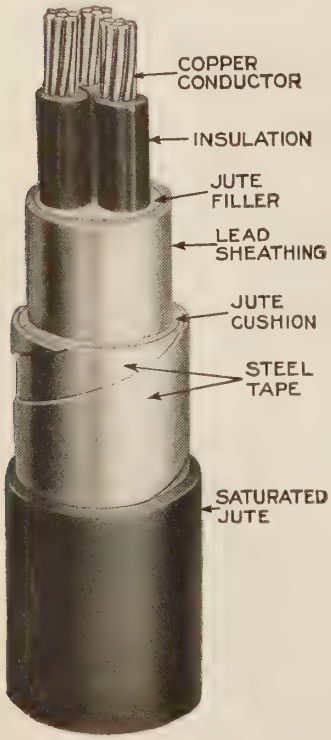
One Quality Only — The Best

OKONITE INSULATION contains never less than 30% by weight (over 60% by volume) of Wild Dry Up-River Fine Para Rubber, with no admixture of low-grade rubber, reclaimed rubber, or rubber substitutes.

OKONITE is compounded with nothing but the highest grade materials and each step in the process of manufacture is carefully checked so as to be absolutely certain that the finished insulated wire will be a uniform and perfect product.

OKONITE compound is calendered to the exact thickness required and backed with sheet tin.

The compound with its tin backing is cut into strips and folded around the tinned copper wire (sheet tin on the outside) and rigidly held in this mould during the process of vulcanization. This not only insures perfect centering of the conductor, but greatly adds to the density of the vulcanized product, increases the tensile strength, prolongs the life, and greatly improves the electrical qualities.




OKONITE
Parkway Cable

Every foot of OKONITE Insulated Wire or Cable is tested before the application of tapes, braid, or other covering and after 48 hours immersion in water.

OKONITE Insulation has been made continuously since 1878 in one quality only. And has proven itself in actual service for the past 42 years to be the acme of rubber insulation and the standard by which all rubber insulations are judged.

OKONITE Insulation is elastic, tough and durable. It will withstand greater abuse than any other insulation on the market. It never fails to meet unconditionally the most searching specifications.

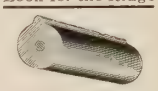
Use OKONITE for safety.

OKONITE Insulation has been proven by 42 years of service to be long lived.

Use OKONITE for economy.

## How Can I Tell It?

It Means the Best
Look for the Ridge



Reg. U. S. Pat. Office

All genuine OKONITE insulated wires bear the trade-mark, a single ridge on the rubber insulation (under the braid), running parallel to the copper conductor.

OKONITE Insulated Wires and Cables are made in any size from the smallest lamp cord to the largest practicable multiple conductor cable, for any service and any commercial voltage and can be furnished in any of the following finishes:

Weatherproof, flameproof, asbestos or steel wire braid.

OKOLOOM.

Lead Covered.

Steel Tape Armored (Parkway Cable).

Steel Wire Armored (Submarine Cable).

Separately or in combination.

OKONITE
Lead Covered Power Cable

OKONITE

TRADE MARK
REG. U.S. PATENT OFFICE.

# OKONITE VARNISHED CAMBRIC

## Insulated Cables

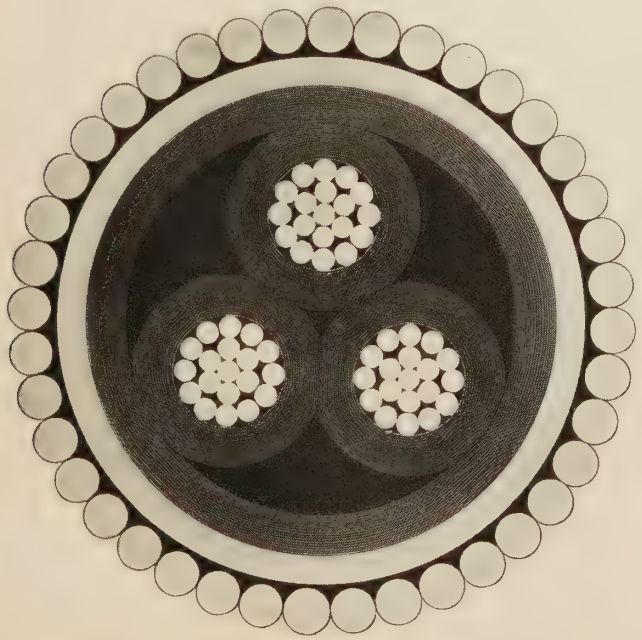
VARNISHED Cambric Insulated Cables, when properly made up of high-class materials, are reliable and long lived when installed under proper conditions.

Due to the fact that the insulation is composed of cloth, hard-baked varnish, and filler, they are particularly well fitted for use in hot and oily places, such as generator, transformer and oil switch leads. They may safely be used for fairly damp locations without a lead sheath, but are not as impervious to water as OKONITE insulated wires and cables.

The same care is used in the inspection and test of raw materials and in the manufacture of OKONITE Varnished Cambric that characterizes all OKONITE products. All Varnished Cambric Cables are given both voltage and insulation resistance tests before shipment, braided cables being tested before application of the braid and while immersed in water.

The OKONITE Company is particularly well equipped to manufacture both large and small, single and multiple conductor varnished cambric power cables for any commercial voltage and with the following finishes:

Weatherproof, flameproof, asbestos or steel wire braid.
OKOLOOM.
Lead Covered.
Steel Tape Armored (Parkway Cable).
Steel Wire Armored (Submarine Cable).
Separately or in combination.



OKONITE Varnished Cambric Submarine Power Cable

# SPLICING MATERIALS

## Manson Tape

The Standard for Friction Tape

MANSON TAPE is a rubber filled cloth tape for protecting joints against mechanical injury. It is adhesive, does not unwrap and does not corrode copper wire. Easily handled, economical to use. Made in black or white.

*We carry in stock black tape only in widths of one-half and three-quarter inch, but are prepared to furnish any width desired.*

*Put up in tin boxes containing one-half pound of tape each—full weight.*

## Okonite Tape

The Standard for Rubber Tape

OKONITE TAPE is a rubber insulating tape for making splices or joints. Joints properly made with OKONITE TAPE are impervious to moisture and are as strong as or stronger electrically and mechanically than the insulated wire itself. Made in black only.

*We carry in stock widths of one-half and three-quarter inch only, but are prepared to furnish any width desired.*

*Put up in cartons containing one-half pound of tape each—full weight.*

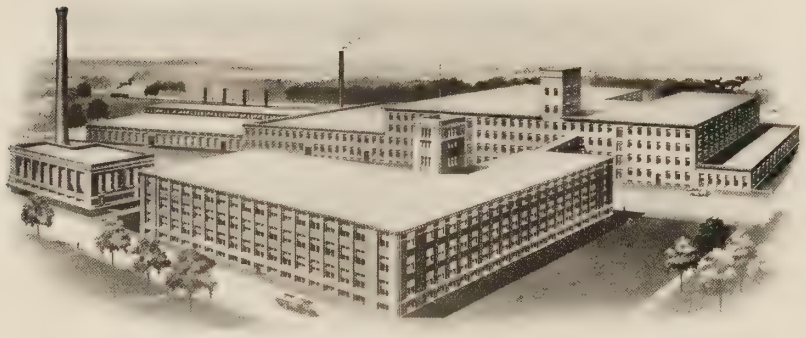
## Okonite Cement

The Standard for Rubber Cement

OKONITE CEMENT is pure rubber in a suitable solvent, and contains nothing that will corrode copper. Only a very small quantity is necessary in making a splice.

It is packed in 2-oz., 8-oz., or 16-oz. cans.

Ask Pettingell-Andrews Company for a complete OKONITE catalog which contains extensive and extremely valuable cable and wire engineering data.



Plant of Phillips Wire Company, Pawtucket, R. I.

FOR over thirty years "O. K." weatherproof wires have been the acknowledged standard with the electrical trade, their reputation having been earned by a durable insulation, desirable finish, and uniform weights.

WEATHER-PROOF TRADE MARK "O.K." LINE AND HOUSE WIRES

BLACK CORE TRADE "PARAC" MARK RUBBER WIRES

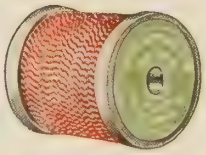
BARE COPPER TRADE PHILLIPS MARK WIRES & CABLES

# INSULATED CONDUCTORS

"O. K." Weatherproof—Triple Braid

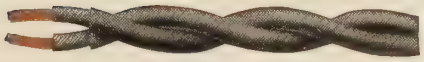
Weatherproof Iron Wire

Slowburning Wire



Annunciator Wire
One Pound Spools

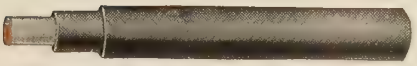
Cross Section of
Concentric Strand



Weatherproof Twisted Pairs

Damp-proof Office Wire

"Parac" Rubber Covered—Double Braid



"Parac" Rubber Covered—Single Braid

"Parac" Rubber Covered—Duplex

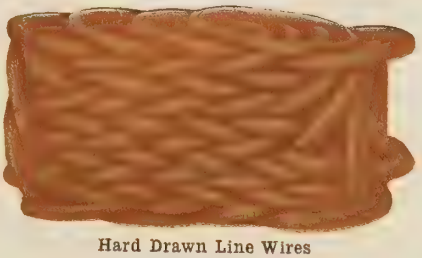
"Parac" Rubber Covered—Stranded

"Parac" Telephone Wires

# BARE COPPER CONDUCTORS

Cross Sections of Trolley Wires

Tinned Copper Strand



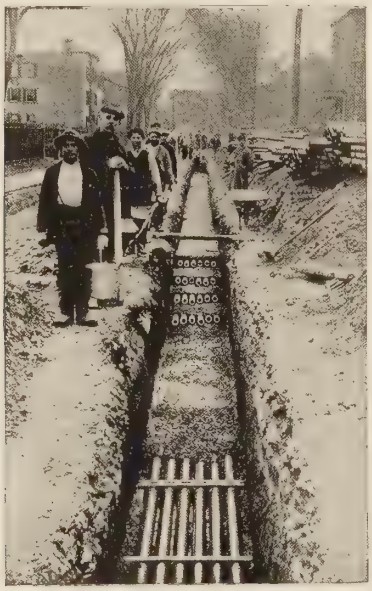
Hard Drawn Line Wires

# JOHNS-MANVILLE FIBRE CONDUIT

## FOR UNDERGROUND SYSTEMS

PROGRESSIVE public-utility corporations are continually striving to increase the use of electricity by lowering rates and improving service to consumers. In working toward these ends, efficient production is a paramount consideration, and it becomes necessary for every department to study each detail with the idea of effecting the greatest possible economy consistent with good performance, so that a proper return on the investment may be secured.

Particularly in the distribution department is it necessary to provide the best and most durable equipment in order to guard against interruptions to service and injuries to auxiliary apparatus. In this case the first cost of installation is often out of all proportion to the immediate returns, and purchases of equipment must, therefore, be made with a broad consideration of ultimate cost rather than of the existing market price. In other words, cost of installation, durability and service features must overbalance initial outlay.



Johns-Manville Fibre Conduit, 350,000 Feet Installed by the Connecticut Co., Hartford, Conn.

In constructing a distribution system, one of the first problems to be solved is whether it is to be underground or overhead. Underground construction, to be sure, is very expensive when compared with the cost of overhead lines. On the other hand, a conduit system is a permanent structure having little or no depreciation, and is immune from the effects of wind, rain and sleet storms, and the consequent service interruption. Furthermore, owing to the constantly increasing demand for electrical energy, the serious objections to the unsightly and ever-present hazards of overhead wires and poles, underground distribution has become a necessity in many places where, under former conditions, this class of service would not have been deemed practicable or the expense warranted.

The ultimate value of a conduit system, of course, does not depend upon its initial cost alone, but rather upon its ability to properly serve and protect the cables and other electrical equipment. On the other hand, the interest on the investment is a large factor in the cost of distribution.

### Johns-Manville Fibre Conduit—What It Is Its Uses and Its Advantages

The largest field for the use of Johns-Manville Fibre Conduit is obviously in electric-service underground systems. It has been satisfactorily applied, however, in many special fields, notably for use with powerhouse-cable systems, for leaders from aerial lines to underground ducts, in industrial plants, for conveying water, oil, brine, ammonia, dilute acids and various corrosive alkali solutions, for laboratory drainage systems and for carrying acid vapors from laboratory hoods.

Johns-Manville Fibre Conduit is a hard, tough conduit, cylindrical in section, and is made from specially treated fibre, or wood pulp, which is formed under pressure, producing a homogeneous mass, which when cut has the appearance of hard rubber. It is impregnated with a permanent bituminous compound which insulates it and renders it waterproof.

Characteristics which have steadily brought Johns-Manville Fibre Conduit to the front are briefly enumerated on the following pages, under the important headings upon which the selection of the most satisfactory type is believed to depend.

### STRENGTH

Johns-Manville Fibre Conduit possesses remarkable mechanical strength. Breakage in shipping, carting, and handling is negligible, whereas that of tile and stoneware conduit often amounts to 10% of a shipment.

### LENGTH

Johns-Manville Fibre Conduit is supplied in 54-inch to 60-inch sections. Compared with the shorter lengths of tile, it saves time and expense in laying and reduces the number of possibly vulnerable joints.

200 feet of Johns-Manville Fibre Conduit on Hand Barrow

### JOINT SIMPLICITY

Johns-Manville Fibre Conduit is furnished with socket, sleeve, drive, or screw joints, as noted herein. The expense of burlap wrapping and special cement required for tile conduit is completely done away with, and joint-making delays reduced to a minimum—it is only necessary to insert one length in another or in a sleeve, or give a few turns, to make up a joint.

### JOINT SMOOTHNESS

The inside of a Johns-Manville Conduit is a continuous smooth tube, and cable can be pulled through with a minimum of effort and without cutting or abrasion of lead sheaths; damage to cables during installation is, therefore, entirely eliminated. This is of prime importance, as about 90% of all cable trouble in tile ducts is directly traceable to injuries to sheathing due to roughness of walls and to cement which has seeped through the butt-joints, hardened, and formed a cutting edge.

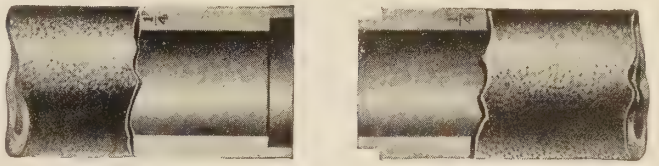
### JOINT TIGHTNESS

The male or spigot end of Johns-Manville Fibre Conduit is lightly tapered, making a perfect fit and providing a joint which can be made water and gas tight.

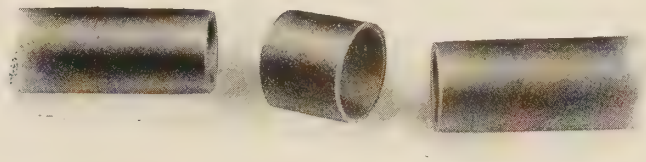
### APPROVED BY UNDERWRITERS

After examination, under the provisions of the National Electrical Code, the Underwriters' Laboratories, Inc., approved Johns-Manville Fibre Conduit, laid in concrete, for central station work.

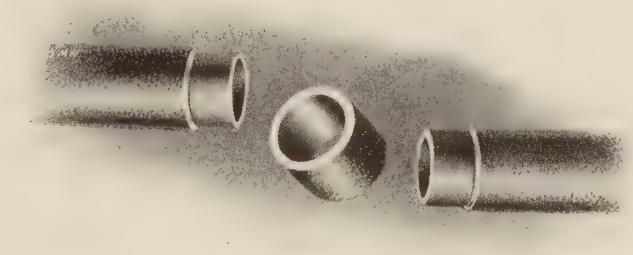
## Style "M" Johns-Manville Fibre Conduit



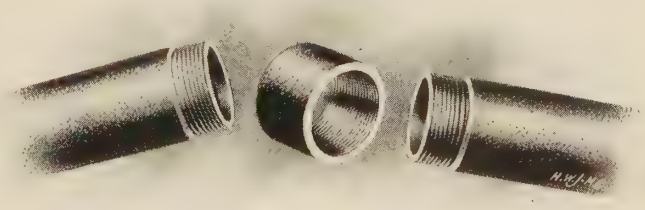
Socket Joint



Drive Joint



Sleeve Joint



Screw Joint

### SERVICE FEATURES

Laid in single ducts and at low cost, Johns-Manville Conduit permits greater flexibility of installation, and ducts may be spread, for instance, to enter manholes. Where necessitated by changes of street grades subsequent to laying, the conduit may be raised or lowered as a whole without destroying the duct. Repairs to cables can also readily be made by splitting the duct. Johns-Manville Conduit, furthermore, is an excellent non-conductor, preventing electrolysis by stray earth currents.

Johns-Manville Fibre Conduit Installation,
Cumberland County Power & Light Co., Portland, Me.

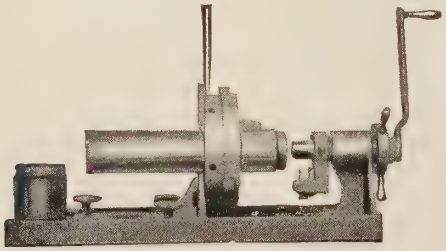
### ELECTRICAL TESTS

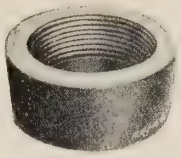
After immersion in water for 200 hours, Johns-Manville Fibre Conduit with walls ¼-inch thick indicates an average puncture test through the wall of 24,000 volts, and when dry an average of 32,000 volts. This is a striking proof of its insulating efficiency.

Johns-Manville Conduit is not inflammable. In case of an arc or flash the area immediately surrounding the arc might char slightly, but fire would not spread.

## Portable Tool for Cutting Johns-Manville Fibre Conduit

It is often necessary to cut a length of fibre conduit for breaking joints or entering a manhole, in which case this tool is very convenient for the purpose. Our customers can rent or purchase the machine.

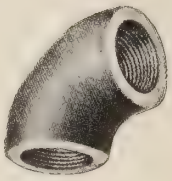




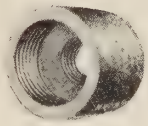
Cap

Tee

Cross



Elbow



Reducer

Junction Box

### INEXPENSIVE FITTINGS

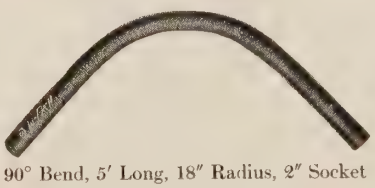
Curves or bends of any degree can be readily made from standard material, and tees, crosses, elbows, junction boxes, etc., are supplied to meet the most complicated requirements. The saving effected here over special and often expensive tile fittings, particularly of the multiple-duct type, may be readily appreciated.

3″ Socket Bend, 90°—36″ Radius

3″ Socket Bend, "S" Type

Bend, 5′ Long, 36″ Radius, 3″ Socket Joint

3″ Screw Bend with Couplings, 90°—36″ Radius



90° Bend, 5′ Long, 18″ Radius, 2″ Socket

# TELEPHONE PROTECTIVE EQUIPMENT

## FOR POWER-TRANSMISSION TELEPHONE LINES

## Combined Double-Pole Fused Switch and Lightning Arrester

THE purpose of this device is to provide means for manually disconnecting the telephone circuit so that the telephone apparatus can be handled without danger, and for automatically opening the telephone circuit (series fuse) in case the induced line current should reach such a magnitude as to endanger the telephone apparatus. The vacuum tube of the arrester is connected between lines and hence tends to equalize potentials between lines. The adjustable air gaps of the arresters are connected between lines and ground for discharging lightning disturbances, thus protecting the telephone equipment against lightning.

Fig. 1
Combined
Double-Pole Fused Switch
and Lightning Arrester
Cat. No. 201111

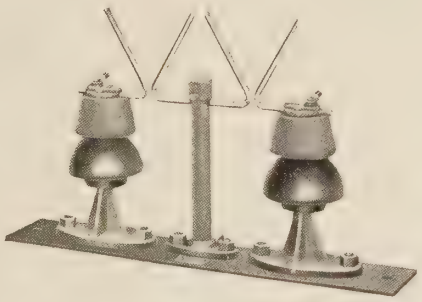


Fig. 2
Double-Pole Horn Gap
Cat. No. 201112

The voltage of the telephone lines on which this device is used must not exceed 250 volts between wires.

## Double-Pole Horn Gap

The purpose of this device is to protect the telephone apparatus, telephone line insulators, and lightning protective equipment against the power line voltage in the case of a cross between the power lines and the telephone line. The other telephone protective equipment is designed to protect the telephone apparatus against lightning and similar transitory disturbances. In case of a cross the fuses on the combined switch and lightning arrester will at once blow, but the insulator on the line side of the fuses and the telephone line insulators will still be subject to the strain of the line voltage. The double-pole horn gap connected outside of the other apparatus provides a means for relieving this strain.

## Telephone Line Insulating Transformers

The purposes of the telephone line insulating transformers are:

1st.—To safeguard the users of telephones from the dangers of high voltage due either to induction, or accidental contact between telephone and power lines, where these lines are on the same pole, or upon a parallel adjacent line of poles.

2nd.—To improve the telephone service by increasing the insulation of the telephone line as a whole through the insulating barrier it places between the interior wiring, instruments, batteries, etc., and the line.

The combination of this transformer with other protective equipment recommended, affords the greatest safety to the telephone instrument and user, even in the extreme cases of actual contact between the high potential and telephone lines.

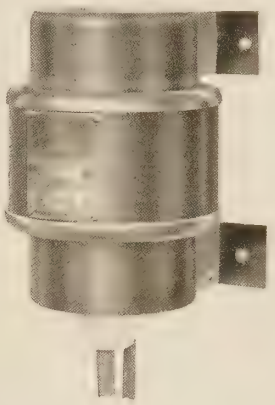


Fig. 3
Telephone Line Insulating Transformer
Cat. No. 221243

If the telephone line is sufficiently well insulated and the protective devices recommended are used, there is no reason why service should not be continued over the telephone line in spite of a ground on the high tension system.

## Specific Recommendations for Protection

CLASS A. *Telephone circuits which parallel power lines, but are not on the same towers or poles and do not cross power lines.*

Disturbances: These circuits are subject to lightning disturbances, and electromagnetic and electrostatic induction. They are not subject to contact with the power lines.

1. Insulating transformers at all telephone stations (Cat. No. 221243).
2. Combined double-pole fused switch and lightning arrester (Cat. No. 201111) at all telephone stations on the line side of the insulating transformer.
3. Drainage coils, preferably one at each end of line.

CLASS B. *Telephone circuits which are carried on the towers or poles with the power lines.*

Disturbances: These circuits are subject to lightning disturbances, electrostatic and electromagnetic induction, and to crosses with the power lines.

Recommendations:

1. Insulating transformers at all telephone stations (Cat. No. 221243).
2. Combined double-pole fused switch and lightning arrester (Cat. No. 201111) at all telephone stations on the line side of the insulating transformer.
3. Double-pole horn gap (Cat. No. 201112) across line at each station on line side of all other apparatus for protection of equipment on telephone circuit in case of a cross with the power lines after series fuses are blown.
4. Drainage coils installed with fuses at each end of line; possibly an additional coil at the middle if the voltage to ground is not held to a safe value by two coils.

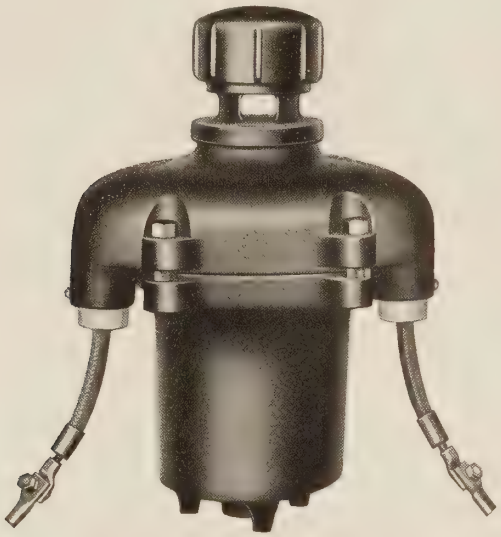
# "D&W" OIL FUSE CUTOUTS

*"Guardians of the Line"*

## They Give Perfect Protection to the Lines Under the Most Exacting Conditions

## They Give Perfect Protection for the Lineman When Re-Fusing

DURING the past few years, public service corporations have spent large sums of money in the interest of the "Safety First" movement. They have conducted campaigns exhorting employees and the public to exercise greater care. They have installed modern apparatus designed to lessen the accident rate among their workmen. Devices that are unsafe in operation or manipulation are in a large measure being eliminated or corrected. In this new order of things the "D&W" Oil Fuse Cutout is being most favorably received by numerous central stations.



Pole Type—50-200 Amperes, 2500 Volts

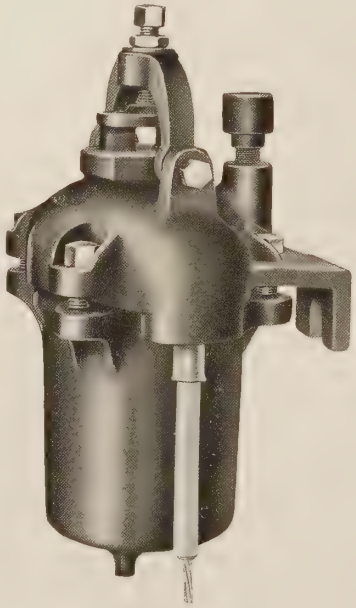
Subway Type with Fuse Carrier Removed

Their use with transformers, and for sectionalizing where the capacity involved is in excess of 15 or 20 amperes, is particularly valuable. The ever-present danger resultant from plugging in on a short circuited line with the porcelain cutout or enclosed fuse is entirely avoided. The automatic safety feature of this cutout, wherein the carrier is locked against blowing out, permits of re-fusing with absolute security under all conditions.

In underground service the frequent presence of gas in the manhole, which may be ignited during the operation of re-fusing cutouts having exposed contacts, introduces risks of no small moment. By the method of arranging for the making and breaking of contacts under oil, as is effected in the Oil Fuse Cutout, the danger from such explosions is eliminated.

In a word, the Oil Fuse Cutout gives complete protection to the workman as well as the circuit.

In protecting transformers, it is economy to install the most reliable cutouts available, since a burned out transformer, interrupted service for long periods, and a further possibility of injury to the lineman, may result in losses which no company can afford to chance.



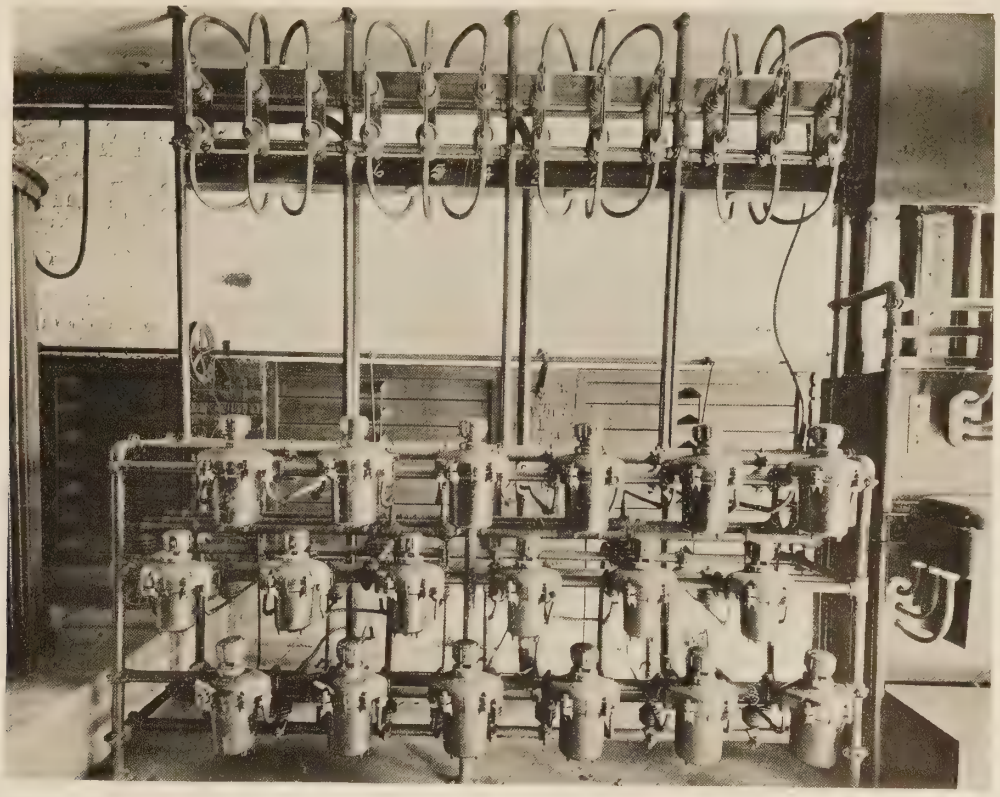
Subway Type
50-200 Amperes, 2500 Volts

"D&W" Oil Fuse Cutouts will withstand a 5,000 k.w. short circuit without stress or injury, giving your line the protection required. They operate quickly under all conditions — no gun-like explosions when the fuse burns out.

## Positive Protection to Men and Equipment

No matter how heavy the overload or surge, whether underground or on overhead lines—no arc can hold when the fuse blows in a "D&W" Oil Fuse Cutout — this protects equipment.

The fuse is easily and quickly replaced and even though there be a short circuit, *no contact is made* until the Fuse Carrier is locked—this protects men.



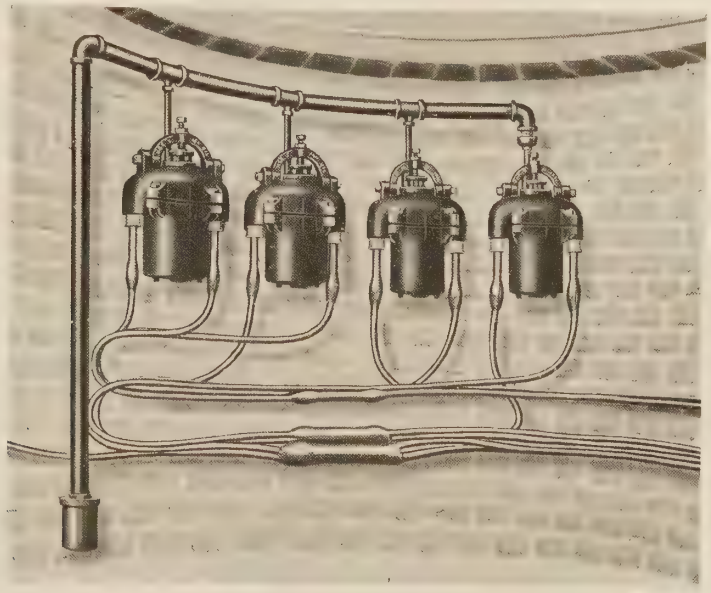
## What Large New England Central Stations Think of the "D&W" Oil Fuse Cutouts

"The 'D&W' Oil Fuse Cutout is the only make on the market capable of operating satisfactorily on 30 amperes or over.

"Our original installation was made in 1913, and since then we have had no trouble whatever resulting from blowouts on the lines where they are in service. I can conscientiously recommend them to any central station superintendent whose requirements are for a cutout on circuits of 2500-volt potential."

"Previous to the installation of the 'D&W' Oil Fuse Cutouts we encountered considerable difficulty with other makes of fuses, especially in wet weather.

"The 'D&W' Oil Fuse Cutouts are doing service on the Company's lines, carrying from 2500 to 4600 volts and have entirely eliminated the difficulties and interruption to service heretofore experienced. We are placing an additional order and will continue to use the 'D&W' Oil Fuse Cutouts, especially where extraordinary service is required."



Installation Showing Method of Venting

Ask Pettingell-Andrews Company for a complete catalog showing "D&W" Oil Fuse Cutouts

# G&W POTHEADS

## A System That Makes Dependable Service Positive

### Gives Greatest Known Flexibility to Distributing Circuits

### Helps to Quickly Locate and Correct Trouble

DISCUSSION as to why potheads should be used is omitted because modern practice recognizes their use as the only "right way" to make up the end of a cable. On request, engineering information will be given in any required degree of detail.

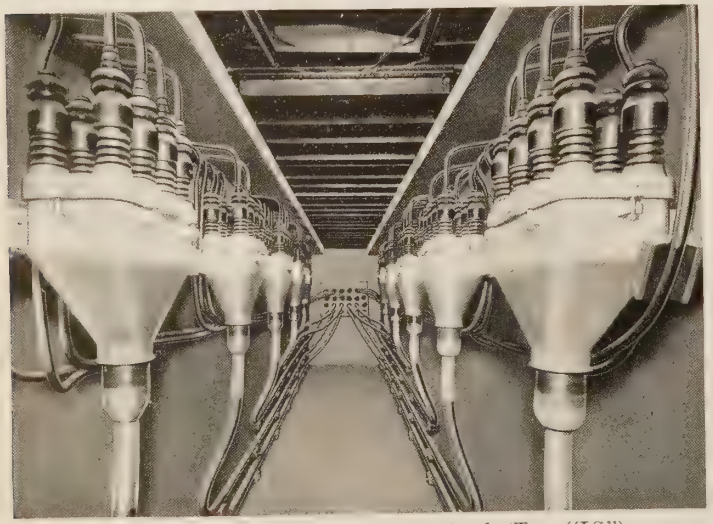
The G&W line of potheads meets the demand for a simple, dependable and inexpensive method of joining high voltage, lead-covered cables to overhead lines without jeopardizing the continuity of the service. Their convenience, reliability, and time, labor and money-saving advantages have established them as a vital adjunct to central station line material.

## Dominant Quality at Low Cost

Starting as pioneers, seventeen years' experience in the design, manufacture and use of potheads has enabled the G&W Company to weed out defects which have developed in service, and to perfect a simple, complete pothead construction.

The elimination of unnecessary parts, combined with highly specialized manufacturing methods, has resulted in the production of potheads of dominant quality and value.

G&W Disconnecting Potheads cost no more than the average plain cable seals (which haven't the disconnecting feature), but they yield a substantially greater measure of service where a device of this kind is indicated.



Installation of G&W Disconnecting Potheads (Type "LS") on Series Lighting Cables

## Ease of Operation

G&W Disconnecting Potheads offer a ready means of making joints secure from breakdown and yet afford the simplest possible means of disconnection in case of emergency. When this device is used, no disconnecting box or switch is required, nor is it necessary to cut the overhead line or unscrew any nuts. The G&W Disconnecting Pothead is disconnected and reconnected instantly, without the use of tools. The lineman simply lifts it from one position and places it in another.

Supplied with choice of cable entrances, it may be installed by linemen of average intelligence. It is therefore especially adaptable where cable jointers are not available.

Being of porcelain, its insulating qualities are of the best.

It is made for four groups of voltages, 0 to 6600—6600 to 10,000—10,000 to 15,000, and 15,000 to 35,000 volts.

## In Asking for Information or Prices or For Ordering, the Following Information Is Essential:

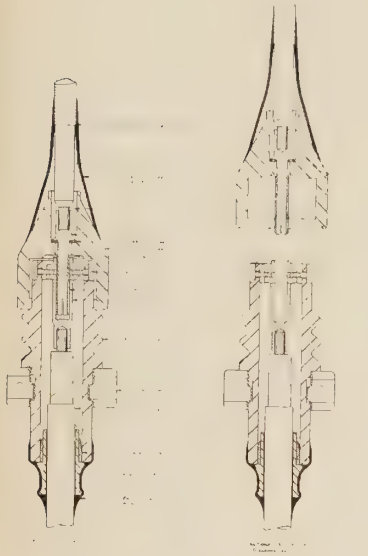
Number of conductors in your cable.
Operating voltage.
Without both of these we can do nothing.

## Desirable

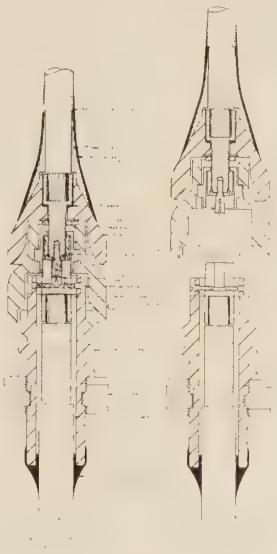
Indoor or outdoor use.
Size of conductor.
Diameter of lead sheath.
Size of conduit.
Type of joint where fiber conduit is used.
Diameter of armor on armored cable.
Shape wanted.
Supporting brackets are furnished on all potheads.
Filling compound is not furnished unless specified on your order.

## Disconnecting Single Conductor

Non-Disconnecting Types can be furnished if desired

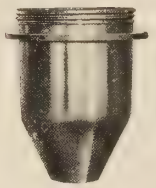


1. Illustrating construction of 100 amp. and 175 amp. disconnecting contacts.

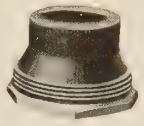


2. Illustrating construction of heavy duty disconnecting contacts.

## Disconnecting Potheads are Furnished with Choice of Three Styles of Cable Entrance

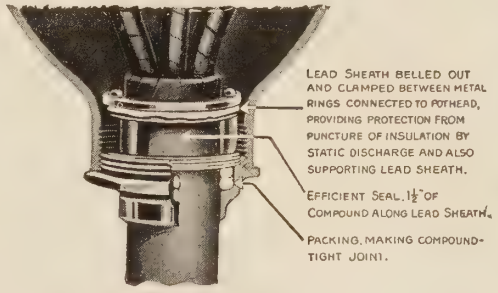


Wiping-sleeve Style of Cable Entrance



Plain Style of Cable Entrance, for Multiple Conductor Pothead.

Plain Style of Cable Entrance, for Single Conductor Pothead


LEAD SHEATH BELLED OUT AND CLAMPED BETWEEN METAL RINGS CONNECTED TO POTHEAD, PROVIDING PROTECTION FROM PUNCTURE OF INSULATION BY STATIC DISCHARGE AND ALSO SUPPORTING LEAD SHEATH.
EFFICIENT SEAL, 1½" OF COMPOUND ALONG LEAD SHEATH.
PACKING, MAKING COMPOUND-TIGHT JOINT.

Combination Stuffing Box and Clamping-ring Style of Cable Entrance, Assembled and in Place, Showing How Cable is Elevated in Compound to a Distance of 1½ inches.

Parts of Stuffing Box and Clamping-ring style of cable entrance ready to be assembled upon cable. Note the Standards that hold the Clamping-ring up in the Compound, and thus allow compound to get 1½ inches below the stripped cable.

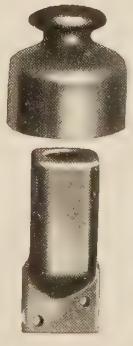
Catalog Nos. 10, 13 or 30, 6,600 volts.

Catalog Nos. 12, 15 or 32, 10,000 volts.

Catalog Nos. 16, 17, or 33, 15,000 volts.

Catalog Nos. 120 and 121, 30,000 volts.

Single-conductor Pothead equipped with Style "WS" wipingsleevecable entrance. This style of cable entrance isfurnished on any single conductor pothead when specified.



Dummy Cap and Dummy Tube

Single-conductor Pothead equipped with Style "SB" stuffing box cable entrance. This style of cable entrance is furnished on any single conductor pothead when specified.

## General Instructions for Installation

Train cable into position and cut off end at a point which brings the ends of the conductors to approximately the desired height. Allowance should be made for fanning out the conductors and for training them inside the pothead properly.

Next, slip the pothead, after removing the lid, over the cable and mark bottom point of pothead on the sheath. Trim lead sheath back, leaving enough of it above marked point so that cable entrance can be made up. Make up the cable entrance. Mount the pot on the entrance. Fan out the individual conductors, so that they train out of their proper outlets.

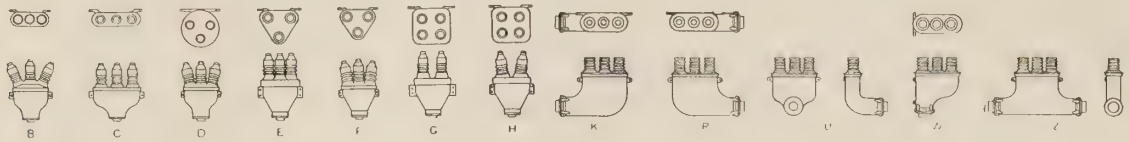
Place the lid in position and mark the conductors for cutting off. Cut off conductors to length which brings their connector in proper position in the outlet.

Disassemble connectors and sweat in conductors. The lugs of all connectors are an individual piece; see that other parts are removed so that temper will not be drawn. Now fill the pot with compound, bolt the lid in position and partially fill the outlet bushings with compound, closing the vent holes in the lid as soon as compound shows there. The insulation on the conductor should end under compound.

Next assemble caps and connector on line wires and close the connections. Where the conductor joint is inside the pothead or outlet bushings on non-disconnecting potheads, the porcelain caps and the lid of the pothead must be shoved back up on the line wires before the joints are sweated.

In taking the line wire into the cap of a pothead, rubber tape should replace the braid for a few inches above the cap as old braid will sometimes have a wick action. Stranded conductors should be tinned solid for the same reason.

## Key to the Shapes Furnished



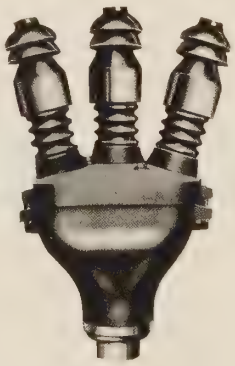

## Multiple Conductor Potheads—For Outside Use

Form "L"—Volts 0-6600
Maximum size of Conductor, 300,000 c.m.
Types "LO," "LS," "LTS"
and
Form "M"—Volts 0 30,000
Maximum size of Conductor, 1,000,000 c.m.
Types "MO," "MS," "MTS"

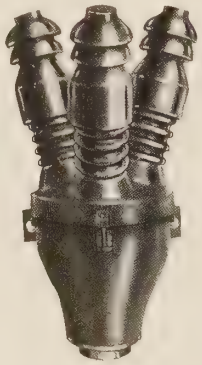
The principles of design are identical in both forms.

Form "L" is a small, more compact pothead used on voltages up to 6,600 where space is limited.

Catalog No. 71 non-disconnecting or 81 disconnecting 6,600 volt, 2-conductor, without cable entrance. Any multiple conductor pothead can be supplied with any one of three types of cable entrance.



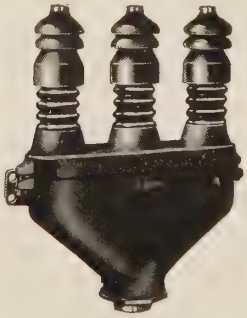
Catalog No. 73 non-disconnecting or 83 disconnecting Shape "B," 6,600 volt, 3 conductor



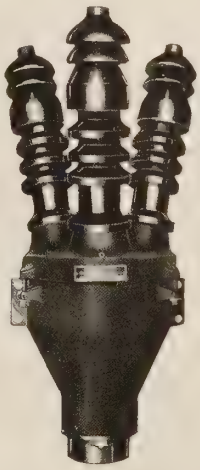
Catalog No. 73 non-disconnecting or 83 disconnecting Shape "D," 6,600 volts, 3 conductor

Form "M" is larger and gives more room inside the pothead for opening up the cable, jointing work, etc. It is also desirable where installers are inexperienced, as its roominess gives a wider limit of adjustment of the cable conductors than does a small pothead.

Catalog No. 42 disconnecting or 62 non-disconnecting Shape "E," 6,600 volt, 3 conductor



Catalog No. 43 disconnecting or 63 non-disconnecting Shape "C," 10,000 volt, 3 conductor



Catalog No. 493 disconnecting or 693 non-disconnecting Shape "F," 15,000 volt, 3 conductor

Potheads for outside use are designed with watersheds, etc., for their protection in severe weather conditions. They are entirely suitable for inside use in every way.

All outside use potheads can be used inside, but inside use potheads are not suitable for use outside.

There is no difference in appearance, shape or dimension between disconnecting and non-disconnecting potheads.

The difference lies in the form of connector used.

Form "L" and Form "M" potheads are furnished with either a combination clamping ring and stuffing box cable entrance or with sleeves for a wiped joint. The no-wiped joint type of entrance is ordinarily furnished where no choice is indicated.

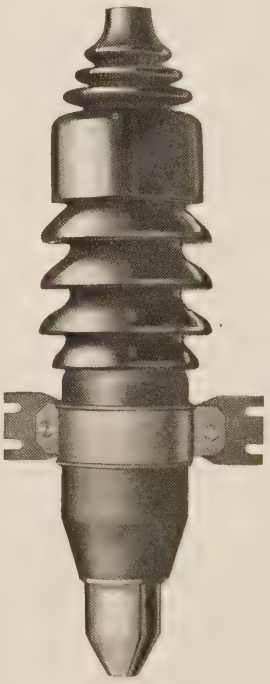
High-grade filling compound furnished when specified.

## THE "MAXIMUM" POTHEAD

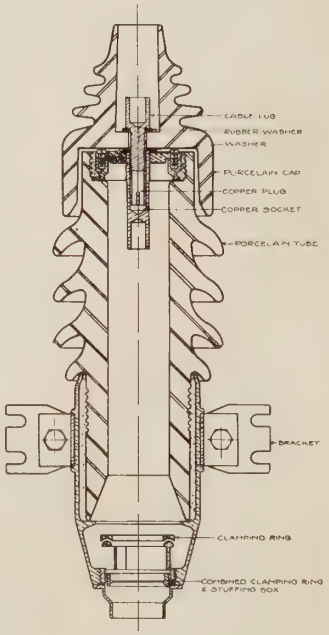
### Not Built for Price but for a Purpose

Essential for all voltages above 13,000.

Made in all voltages, single and multiple conductor, up to and including 35,000 volts.



Type "SS" or "OO," 30,000 volts. Illustrating the rugged construction and ample porcelain.



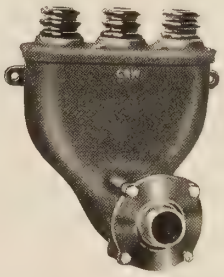
## Multiple Conductor Potheads—For Inside Use

Form "N" Form "P" Form "Q"

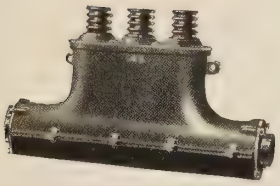
Forms "N," "P" and "Q" are non-disconnecting potheads especially designed for inside use.

Any pothead for outside use can be used inside, but inside potheads are not designed for outside weather conditions.

Form "N," Shape "C"
6,600 volts

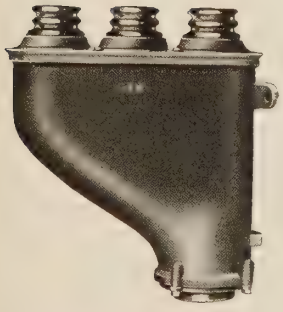


Form "N," Shape "U"
6,600 volts

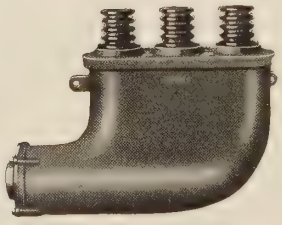


Form "N," Shape "Z"
13,500 volts

Form "N," Shape "D"
6,600 volts



Form "N," Shape "W"
6,600 volts



Form "N" Shape "K"
13,500 volts

Fig. 6
Type Q

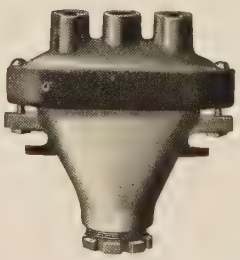
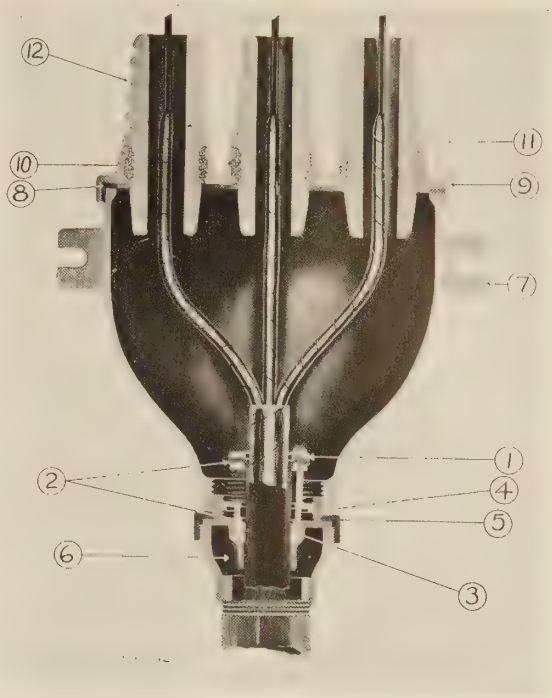


Fig. 5
Type P




## Why You Get More for Your Money in G&W Potheads

1. Brass ring mechanically supporting and bonding cable without crushing strain on cable sheath.

2. End of lead sheath mechanically belled out at least one and one-half inches in compound. This elevation of complete cable into the compound provides absolute protection against moisture.

3. Soft packing to prevent leakage of compound, compressed by screwed gland.

4. Sizes of openings standardized and all types of cable entrances (clamped ring, wiping sleeve or plain plug) universal.

5. Universal nut when conduit coupling is desired. All sizes of conduit couplings interchangeable.

6. No leakage of compound into conduit or coupling. No packing of coupling required.

7. Bracket slotted for convenience in installing.

8. Rubber gasket seated upon ground surface with bolted cover makes joint compound tight, allowing outlet tubes to be filled with compound.

9. Substantial metal lids. To obviate heating on large sizes, non-magnetic metal is used.

10. Outlet bushings cemented to eliminate moisture or dirt inside pothead.

11. Proper thickness and quality of porcelain.

12. Large leakage surface for rated voltage.

Standardized construction with universal fittings enables quick shipments of any shape or size of pothead for upright, horizontal or inverted use. Any pothead can be supplied with bolted cable entrance if turning of bell must be avoided. The most complete standardized line. Built for dependability.

# FLOODLIGHTING PROJECTORS

## For Spectacular, Commercial, Industrial, and Protective Lighting

FLOODLIGHTING, or illumination by projection, first received world-wide prominence at the Panama Pacific International Exposition. The spectacular effects produced by floodlighting the buildings and beautiful works of art created a demand for similar results all over the country.

To meet this demand the General Electric Company developed and placed on the market a complete line of floodlighting projectors which meet the requirements for spectacular, commercial, industrial, and protective lighting.

Floodlighting of Lynn, Mass., Library

The spectacular effects produced by floodlighting are well known, but the commercial value and effectiveness of floodlighting signs painted on water towers and chimneys, as well as billboards mounted on the tops of buildings or on the sides of railway tracks and highways, are now being more and more appreciated.

For industrial purposes floodlighting projectors are used to facilitate night work in shipyards, quarries, docks, etc., and also to illuminate the yards of industrial plants and railways so that transportation can proceed at night with daylight efficiency. Well-lighted yards also lessen the probability of accidents.

The protection afforded by floodlighting bridges, docks, arsenals, fences, and yards of industrial plants and various other strategic points has been so essential that this form of lighting is now of the greatest importance in protecting property.

On the following pages a line of standard floodlighting projectors is described, and sufficient data are given for selecting the proper projectors for various kinds of work.

Our Illuminating Engineering Department will prepare specifications and recommendations on any lighting proposition. This is another P-A feature.

Send your lighting problems to Pettingell-Andrews Co.

### Glass Reflectors and Lenses

A properly designed and constructed silvered glass reflector is the most durable and efficient device for light projection. The General Electric Company has worked for several years in perfecting this product, and the result of this research work is the copper-backed glass reflectors now standardized for GE floodlight projector.

Glass reflectors of various forms and shapes, depending upon the class of work for which the projectors are used, are silvered on the back. Owing to the silver being more or less sensitive to atmospheric conditions, a coating of copper is applied by special process over the silver. This copper backing hermetically seals the silvering, protects the glass, and also assists in radiating the heat. Silver-plated and copper-backed glass reflectors, therefore, have a permanent reflecting surface and a protection for the silvering from mechanical injury and deterioration by the elements.

Glass lenses are constructed to redirect light from a floodlighting projector so that beams of various shapes and spreads can be obtained.

In connection with floodlighting there are a few special cases where desired results can be better obtained when the projector is equipped with a special type of lens, and to meet such cases, the Pettingell-Andrews Company can supply diffusing and prismatic types of lenses for their floodlighting projectors.

A diffusing lens greatly increases the spread of a beam, and if such a lens is placed in a projector having a beam divergence of 10 degrees, the resulting beam will have a spread of 50 degrees or more depending on the type used. A beam of this character is well adapted for floodlighting large objects or surfaces at close range.

Some prismatic types of lenses produce a rectangular shaped beam which is very long and narrow. Such lenses placed across a beam of 10 degrees divergence will spread the beam to approximately 50 to 90 degrees in the horizontal plane; the divergence remaining 10 degrees in the vertical plane. A beam

of this formation is recommended for floodlighting a long and narrow sign or large areas.

In addition to the various types of lenses, the Pettingell-Andrews Company is in a position to furnish a metal shield which will eliminate any objectionable stray light from their floodlighting projectors.

These shields will prevent the stray light from illuminating the property or guard that should be in darkness.

## Form L-1 Projector

This projector is particularly recommended to illuminate a surface or object located 150 feet or more from the projector, as the beam divergence is from 8 to 14 degrees.

## Medium Angle Form L-1 Projector

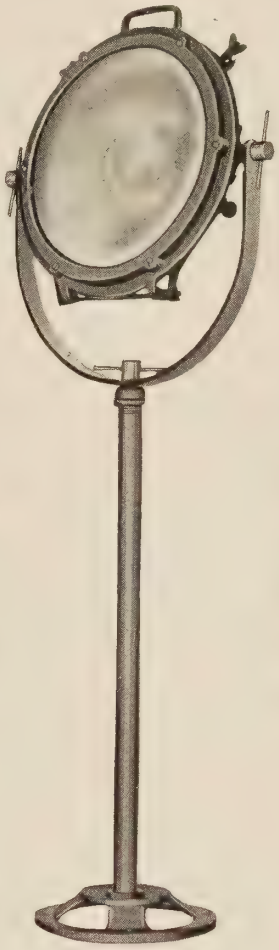
This projector is recommended to illuminate objects located from 75 to 200 feet distance as the beam has a divergence of 12-20 degrees.

The construction of this projector is along the lines of the Form L-1 previously described, except that the aluminum reflector is of special design to give the required beam divergence.

## Form L-3 Projector

Where it is necessary to mount the projector within 75 ft. or less from the object to be illuminated, the Form L-3 projector should be used as it has a beam divergence of approximately 50 degrees.

This projector is supplied with either the hinged base, the swivel and trunnion base, or the swivel and pipe stand base. The best results are obtained with the 500-watt floodlighting lamp, although the 250-watt floodlighting lamp with a Cat. No. GE 070 adapter can be used.



Illustrations
Show Types of Mounting

## Form L-9 Projector

For the illumination of objects located at a distance of 150 feet or more, it is recommended to use the Form L-9 projector as it has a beam divergence of 10-16 degrees.

Except for the special silvered and copper-backed, heat-resisting glass reflector, this projector is similar in construction to the Form L-1.

This projector is supplied with either the swivel and trunnion base, or the swivel and pipe stand base.

Floodlighting Used in Construction Work

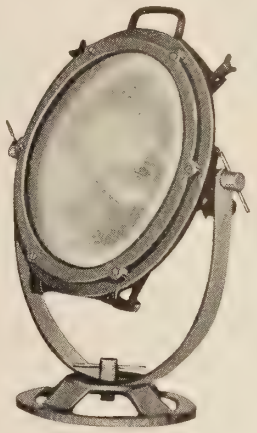
## Form L-11 Projector

The Form L-11 Projector meets the demand for a small floodlighting unit that can be mounted close to the object to be illuminated.

## Form L-12 Projector

This projector has recently been designed to take care of large area lighting such as shipyards, railway centers and construction work, as it has a beam divergence of 20-30 degrees.

The reflector is made of heavy heat-resisting glass 15½ in. diameter, silvered and coppered on the back and composed of three reflecting surfaces which utilize 60 per cent. of the light from the lamp, or a total of 85 per cent. when taking into consideration the amount of direct light which enters the beam. The glass is so constructed that a slightly diffused and even beam is projected.



On the top of the reflector and protected by a ventilating cowl is a focusing mechanism, and on the bottom an opening is provided so that cool air can enter the reflector, circulate around the lamp, and leave by the top ventilator. Both openings are fitted with screens to prevent insect nuisance. The regular type 110- or 220-volt, 300- to 1000-watt lamps can be used.

This projector is supplied with either the swivel and trunnion base or the swivel and pipe stand base.

## Form L-15 Projector

The Form L-15 Floodlighting Projector is similar to the Form L-12 except that the glass reflector is placed inside of a sheet metal casing. The casing is equipped with a sheet metal door which is hinged on the side and provided with a suitable latch.

On the bottom of the casing is a baffle air intake, which permits cool air to enter the casing, circulate around the lamp and reflector, and leave by the ventilating cowl located on the top of the casing. A suitable handle for manipulating the projector is attached to its back.

A focusing mechanism is located inside of the ventilating cowl so that maximum and minimum beam divergence can be obtained.

Regulator type 110- or 220-volt multiple lamps from 300- to 1000-watt sizes can be used.

This projector can be furnished with either the swivel and trunnion base or the swivel and pipe stand base.

# WESTERN RED CEDAR POLES

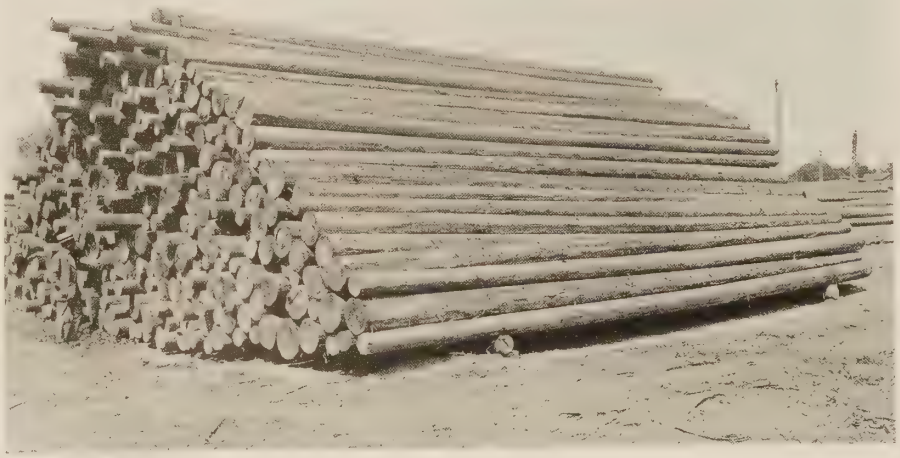
## Strong, Straight, and Sightly—Together With Longest Life
## The Lowest Cost per Year of Service

THE New England supply of chestnut and cedar rapidly becoming extinct, the Pettingell-Andrews Company have arranged to act as exclusive New England distributors for the Valentine-Clark Co. of Spokane, Washington, who are one of the largest producers of Western Red Cedar Poles in the country.

### 75,000 to 150,000 Poles on Hand

The Valentine-Clark Co. maintain the largest concentrating yard in the east (situated on the lines of three transcontinental railroads), where they carry at all times a complete stock of Western Red Cedar Poles in all specifications, thus enabling prompt shipment and Exemplar Service.

Wherever the facts are known about Western Red Cedar Poles, whether at home in the mountains where they are grown or 3500 miles away on the Atlantic sea border, they are used by progressive utility companies.



Western Red Cedar—Wood's Run. Note uniform straightness and minimum butt rot
Smooth surfaces, straight grain, and absence of blemish

## Strength Combined with Light Weight and Elasticity

Western Red Cedar has practically the same strength as chestnut with about one-half the weight.

Western Red Cedar has greater elasticity than any other pole in use.

Because of their strength and exceeding long life, they give the greatest guarantee of continuity of service.

Northern White Cedar—Wood's Run. Note comparison with Western Red Cedar as to butt rot and general appearance of pole

Western Red Cedar Poles will outlast any other pole in its natural state.

## Sightly Appearance

Western Red Cedar Poles are uniformly straight in appearance and are free from large knots. They have rapidly become the favored pole for city use.

### Low Maintenance Cost

Western Red Cedar Poles cost less to handle and erect because of their uniformity of shape, smoothness, and extreme light weight, showing a saving in time of framing and erecting. These features, coupled with their great strength and long life, guarantee a continuous service of from sixteen to twenty-five years.

Figured on an annual maintenance basis a Western Red Cedar Pole is lowest in cost per year of service.

## Length of Poles

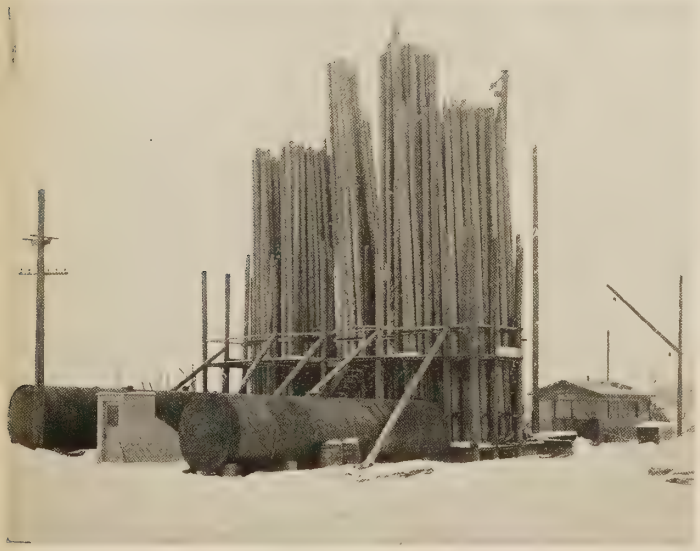
Range in length from 25 ft. to 85 ft., with top diameter up to 10 inches.

## Butt Treated Poles

Western Red Cedar Poles can be furnished butt treated according to standard specification.

Full information furnished by Pettingell-Andrews Company on application.

Because of the straight, fine appearance of Western Red Cedar Poles they have rapidly become the favored pole for city use.



The Valentine-Clark Co. Butt Treating Plant
Tank contains 145 B-50s, 16 B-60s, 36 B-65s Western Red Cedar Poles

## Over the Continental Divide

Western Red Cedar Poles carry the high power lines of the Chicago, Milwaukee Railway Electrification over the Continental Divide. In fact, Western Red Cedar Poles were selected to carry this, the greatest piece of electrical construction in the world, from start to finish, as well as others.

The poles shown here are at Pipestone Pass Tunnel, 16.8 miles east of Butte, on the Continental Divide.

The pole in the foreground supports 1060 pounds weight, as represented in three No. 00 6-strand hemp core, copper cables, 1¾ in. Siemens-Martin 7-strand steel cable, over a span of 815 feet, in addition to the cross-arms and necessary hardware.

Exposure to mountain winds under such tremendous loads soon proves the quality of a pole. Western Red Cedar has stood the test. When the long life and sightly qualities are added, you will find there is nothing that fills the requirements at so reasonable a cost for these heavy lines as Western Red Cedar Poles.

# "EXEMPLAR" CROSS-ARMS

## Long-Leaf Yellow Pine (Pinus Palustris) — 80% to 100% Heart

## Guaranteed 75% Heart at *ANY* Cross-Section

These Arms can be furnished Unpinned and Unpainted

Or — Pinned and Painted

The following sizes are carried in stock. The 3¼x 4¼-inch bored for ⅝-inch through bolt and two brace holes for ⅜-inch carriage bolts. The 3¾x4¾-inch bored for ¾-inch through bolts and two brace holes for ⅜-inch carriage bolts.

Size Finished, 3¼ x 4¼ Inches

| Length of Arm | No. of Pins | Size of Pin Inches | Pin Spacing, Inches End | Center | Side |
|---|---|---|---|---|---|
| 3 ft. | 2 | 1½ | 4 | 28 | .. |
| 4 ft. | 4 | 1½ | 4 | 16 | 12 |
| 5 ft. 6 in. | 4 | 1½ | 4 | 30 | 14 |
| 6 ft. | 6 | 1½ | 4 | 16 | 12 |
| 8 ft. | 6 | 1½ | 5 | 30 | 14 |
| 8 ft. | 8 | 1½ | 4 | 16 | 12 |
| 10 ft. | 10 | 1½ | 4 | 16 | 12 |

Size Finished, 3¾ x 4¾ Inches

| | | | | | |
|---|---|---|---|---|---|
| 5 ft. 6 in. | 4 | 1½ | 4 | 30 | 14 |
| 7 ft. 10 in. | 6 | 1½ | 4 | 30 | 14 |
| 10 ft. 2 in. | 8 | 1½ | 4 | 30 | 14 |

We are prepared to furnish "Exemplar" Cross-Arms in all sizes from our Southern mill.

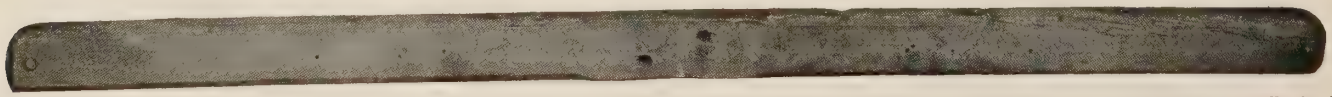
## Cross-Arm Materials

For outside construction we are confined to the Conifers, on account of the liability of the Hardwoods to warp.

The Conifers vary in *strength* about in proportion to their weights. Forest Service breaking tests on cross-arms 3¼x4¼ inches by 6 feet yielded the following results in lb. per square inch, from which it is evident that the same strength may be obtained by substituting a smaller Long-Leaf arm for that of any of the other conifers, making its weight the same, but reducing its footage and cost, this reduced footage and cost being represented by percentages in the second column:

| | Strength in lb. per square inch | Reduced Footage |
|---|---|---|
| Long-leaf Yellow Pine . . . . | 10,900 | |
| Loblolly Pine . . . . . | 10,100 | |
| Shortleaf Yellow Pine . . . . | 9,260 | 84.95% |
| White Pine . . . . . | 7,900 | 72.48% |
| Red Cypress . . . . . | 7,900 | 72.48% |
| Shortleaf Pine, Creosoted . . . | 7,650 | 70.18% |
| Douglas Fir . . . . . | 7,590 | 69.63% |
| White Cedar (Juniper) . . . . | 5,200 | 47.70% |

Accurate figures for comparative *Resistance to Decay* are not obtainable, and would of course vary with the climate.



This cross-arm was installed for service in 1890, and was removed from the pole in 1911, because of line changes. It was sent to us by a Central Station in New England as an example of the long life of genuine Long-Leaf Yellow Pine Cross-Arms. This arm has been in the Pettingell-Andrews Company warehouse ever since, and today, after twenty-one years' service on a pole line, and nine years in our warehouse, is as strong and solid as new timber and the only sign of decay is about one-half of one inch of sapwood in one corner. Otherwise the arm is perfect.

LONG-LEAF YELLOW PINE has been for many years the standard for outside construction, and its great durability has always been recognized. One central station has on exhibition Long-Leaf cross-arms taken from the poles after 23 years of service. The sap wood has disappeared but the heart wood is as sound as ever. Another central station reports that Long-Leaf arms, placed on its poles in 1896, are giving good service today. We have been making Long-Leaf cross-arms for fourteen years, and as far as we know every arm we have ever sold is now giving good service.

SHORTLEAF and LOBLOLLY PINE usually decay in this climate in from three to five years.

CREOSOTED SHORTLEAF PINE resists decay as well as, but not better than, Long-Leaf.

RED CYPRESS, "The Wood Eternal," is believed to resist decay better than any other wood.

WHITE CEDAR, marketed in cross-arms as "Juniper," is believed to resist decay quite well.

DOUGLAS FIR has been exploited as the coming structural timber to take the place of Long-Leaf when the supply of the latter is exhausted. It is in no way equal to Long-Leaf. It is stiffer, more brittle, and splinters more readily, besides being inferior in strength. Great claims have been made for its durability, but its use in this climate is too recent to confirm them. What was claimed to be the best proof of its durability was a case of the preservation of fir arms on the poles for 49 years at a point in Nevada, but investigation showed this point to be practically rainless.

We operate in LONG-LEAF therefore simply because, with the rigid inspection we have learned how to practice, we are sure it will give the greatest service, and expect to do so until its increasing scarcity makes its price prohibitive.

RED CYPRESS is probably the next best cross-arm material, having the greatest durability together with a fair strength. It can never come into general use for cross-arms because even now its scarcity makes the price almost prohibitive. We are able to obtain a limited supply at present, and can supply those who require it.

DOUGLAS FIR is the next choice, and the stands are so great that a supply should be obtainable at reasonable prices for a great many years to come. We therefore contemplate using fir when Long-Leaf is no longer obtainable. For some years to come, however, we expect to be able to obtain the genuine virgin Long-Leaf Yellow Pine, which has earned its great reputation for durability and strength; and our complete plant operating from tree to the finished cross-arm enables us to supply it with the most rigid inspection, at the lowest possible cost.

# "EXEMPLAR"
# LOCUST PINS

## Made of Thoroughly Seasoned Young, Second Growth, Straight-grained Locust

As a result of a multitude of experiences, many of them unfortunate and exacting tests extending over a considerable period of time, it has become a universally recognized fact that the only material which satisfactorily meets the requirements of insulator pins is locust wood.

Locust wood permits the manufacture of a pin that presents a hard, smooth surface to the elements. Only locust has the strength sufficient to withstand so great a strain on so small a piece of wood. Only locust has the durability to resist decay—the most important factor in decreasing the expense of line repairs and renewals.

But merely "locust" is not enough. Even genuine locust pins found in the market, bear traces of the far-reaching ravages of the "bore" beetle and the "doze" fungus. To meet the demand for a perfect pin, "Exemplar" Locust Pins are made only from sound, straight-grained portions of buttlogs, which usually represent not more than one-fifth of the entire butt. The result is a sound, well-made pin, straight-grained, free from knots, "doze" and "bore"—unquestionably the best pin that can be made.

## Free from Splits and Knots or Checks

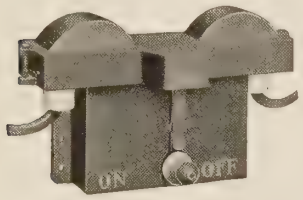
## Every Pin is Stamped "Exemplar"

## Guaranteed Perfect

# WEATHERPROOF OIL SWITCHES

THE weatherproof oil switches listed here were placed on the market several years ago and have been installed under all conditions by a large number of the central station companies throughout the country, and have given, and are giving, entire satisfaction to their users.

The virtues of oil break switches are well known, and the design, as embodied in our switches, meets all reasonable requirements demanded in weatherproof oil switches.



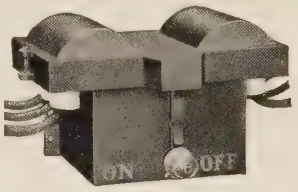
SP

DP

They have a large field, and among the many uses to which they may be put, might be mentioned the following: disconnecting switches for constant current transformers and reactive coils, banks of transformers, building entrances, synchronous and induction motors, insulating feeders and mains at junction of overhead and underground wires, and when properly waterproofed, in manholes.

The manhole switch is subject to special quotations upon receipt of specifications.

These switches are easily installed on poles or hung in manholes, but in view of the various requirements, hangers are not furnished except on order with specifications. Leakage of oil, due to capillarity, is guarded against in the design. Care should be exercised when filling switches with oil, to settle properly into all spaces before putting on cover.



TP

4P

One inspection per year of the oil depth is recommended as is usual in the case of transformers.

Renewal of oil should depend upon the frequency of operation of switch, following the general practice usual in the case of switchboard switches.

We guarantee their performance within their rated capacity, and at any power factor.

We do not provide oil, as practically all central stations have it in stock for transformers.

## In addition to material listed in this catalog, Pettingell-Andrews Company carry a complete stock of Electric Lighting Supplies, Appliances and Fixtures, among which are the following best known makes:—

GE Wiring Devices
American, Galvanite, Greenfield duct (rigid conduit)
Sprague Genuine BX Cables
Sprague Boxes
Wireduct
Wiremold
D & W Cutouts and Fuses
Condulets
V. V. Fittings
Paiste Taplets
Edison Mazda Lamps
Miniature Lamps
Eveready Daylos
Columbia Batteries and Carbon Brushes
Panel Boards
Ralco Specialties
Hubbell Specialties
Hemco Plugs
Faraday Gongs and Bells
Couch Telephones
Pyrene Fire Extinguishers
Palmer Safety Switches

### Appliances

Thor Washers, Ironers and Vacuum Cleaners
Edison—Hotpoint—Hughes—sewing machines, bake ovens, ranges, appliances
GE Fans
Shelton Vibrators
Kent Heavy Duty Vacuum Cleaners
Utility Floor Machines
Standard Electric Cookers
Hamilton-Beach Specialties
Violetta-Violet Ray Outfits

### Fixtures

National X-Ray Direct Reflectors and Indirect Fixtures
Four-In-One Units
Celestialite Glassware
Ivanhoe-Regent Shades and Reflectors
Duplexalites
Mohrlites
Eye Shield Diffuser

# HUBBARD POLE LINE HARDWARE AND PEIRCE CONSTRUCTION SPECIALTIES

MADE exclusively from Open Hearth Steel having a tensile strength of 55,000 to 65,000 pounds per square inch.

Hot galvanized and double dipped. Meets *All* specifications of the A. T. & T. Company.

## "If It Isn't Satisfactory, Return It for Credit"

This guarantee applying to Hubbard Pole Line Hardware and Peirce Construction Specialties has been in force since their introduction. It is still in force, and it is being constantly strengthened by an ever increasing rigidity of inspection both of raw materials and of finished product.

Back of this guarantee is the largest manufacturer of Pole Line Hardware and Construction Specialties in the world and the largest distributors of Pole Line Hardware in New England.

The use of this standard material is the safest insurance against line breakdown.

## Please Note

While only a few of Hubbard and Peirce specialties are shown here, Pettingell-Andrews Company carry at all times their complete line, as well as a complete and extensive stock of all materials used in line construction.

Ask Pettingell-Andrews Company for a catalog showing the complete line of Hubbard Pole Line Hardware and Peirce Construction Specialties.

## Peirce Presteel Pin

There has been a strong tendency on the part of Distribution Engineers to adopt metal pins for primaries as well as high tension lines, but there has been no satisfactory pin meeting all conditions of this service, particularly on voltages from 2200 to 13,000.

Wood pins digest and disintegrate from the constant leakage.

This new Presteel Pin meets all objections.

It has the requisite strength when new and it retains this strength throughout its life.

It fits on either wood or steel arms, on arms bored for any size of pin, and on any size of arm.

It is fastened to the arm with either a ½″ or ⅝″ standard through bolt. The nut fits within the body of the pin and is held from turning.

Presteel Pin with Short Bolt

It is guaranteed to break a No. 6 hard-drawn Copper Conductor with the strain applied in any direction.

Made for both round and flat top arms and for 1″ and 1⅜″ insulator bores.

Presteel Pin with Long Bolt

## Peirce Forged Steel Pins with Separable Thimbles

These pins are made in three series of strengths: a 1,500-lb. series, a 3,000-lb. series and a 4,500-lb. series, each developing its rated strength on a dead end pull exerted at the pin top, with a deflection of less than 10 degrees. Each of these series is made in heights ranging from 4 to 16 inches above the arm, so that the correct pin for any style of insulator made by the insulator manufacturers can be selected. The taper of the shank of the pin is so designed that a 1,500-lb. series, 16-inch pin will, in spite of its greater lever arm, withstand a strain of 1,500 pounds just as a 4-inch pin in the same series will.

*We guarantee the new Peirce Forged Steel Pin in any type or size to stand the application at the pin top of a dead end strain equal to its rated strength, with a deflection of less than 10 degrees and without danger to the insulator.*

Each of the series is made in two distinct types: The long bolt pin for wood arms, and the short bolt pin for steel arms. The pin is a solid forging from a single block of steel, and has

neither welds nor joints. Its strength is uniform in all directions. There are no flanges or webs which must be placed in line with the strain. There are no projections to concentrate electrostatic stresses.

The thimble is drawn seamless from sheet steel, and the threads are pressed; the threads on the interior engaging with the threads on the pin top, and those on the exterior engaging the cement.

The practice of having the thimble cemented into the insulator at the insulator factory where, because of the better facilities, a better job can be done at lower cost, is today almost universal and the light weight of this drawn steel thimble is, therefore, of importance. The average weight of a malleable or cast iron thimble used on other types of pins runs between ¾ and 1 pound each. The weight of the drawn steel thimble is less than 2 ounces, so the saving in freight in delivering the thimble to the insulator factory and in delivering the finished insulators with thimbles to the job is an important item.

Note this Illustration carefully

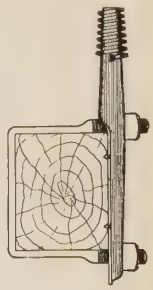
It shows how the full strength of the pin is brought up to the top of the thimble.

An extremely important feature is the prevention of the expansive force of the pin and thimble affecting the insulator. Recent investigations have proved that electrical fatigue of porcelain is really of mechanical origin. The constant mechanical stresses set up in an insulator by the alternate expansion and contraction of the pin or thimble, while insufficient to rupture the insulator, do in time change its molecular structure, and its insulating qualities therefore deteriorate.

This expansive action is completely eliminated in the Peirce Drawn Steel Thimble. The expansive force is very small because of its thinness. It creates no strain in the insulator. If it is screwed tightly upon the solid steel pin, the expansion of the pin would be communicated to the thimble, but provision is made to prevent this. In the top of the thimble is a cork disk. The threads of the thimble loosely fit the threads of the pin. As the pin expands, its threads ride farther up on the thimble threads and the cork disk compresses and takes up the strain.

## Peirce Clamp Pins for Low Voltage Circuits on Wood Cross-Arms

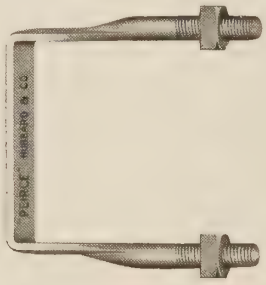
With Peirce Clamp Pins you use all of the timber you pay for. There are no pin holes and therefore no roof is necessary. You can use a smaller sized arm, thereby saving considerable expense, and still get greater original strength. And instead of helping the natural checking and splitting of the arm, Peirce Clamp Pins prevent it absolutely. Observe sketch C. Note how the fibers of the arm are clamped together with a solid band of steel. These drop forged open hearth steel cross-arm straps are so flexible that, as the nuts are tightened, the straps are brought into solid bearing against all sides of the arm, preventing checking in any direction.



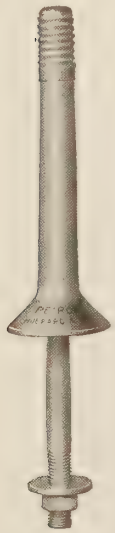
Sketch C

Your cross-arm manufacturer will guarantee a life of twenty years for unbored arms with Peirce Clamp Pins against an average of not over six years for bored arms with wood pins, so the cost of three arms with wood pins and the cost of replacing them, together with the constant hazard to life and property and the expensive interruptions of service, should be balanced against the cost of one smaller arm with Peirce Clamp Pins, which shows a big credit balance in favor of the Clamp Pins.

No. 4300



Straps for No. 4300 Pin



Assembly for Flat Top Wood Arm

Assembly for Steel Arm

Assembly for Round Top Wood Arm

## Cross-Arm Straps

Hot Galvanized

Peirce Cross-Arm Straps are drop forged from round steel and have a broad flat bearing on the arm, which helps to hold the pins firmly upright, By drop forging from round stock, freedom from flaws is assured, and the threads are always uniform in size.

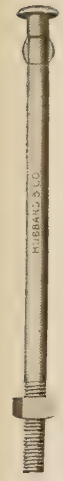
| Stock No. | Dimensions in Inches Size Arm | Size Strap Flat | Round | Per 100 Weight Pounds |
|---|---|---|---|---|
| 1001 | 3¼ x 4¼ | 5/32 x 1⅛ | ½ | 91 |
| 1002 | 3½ x 4½ | 5/32 x 1⅛ | ½ | 102 |
| 1003 | 3¾ x 4¾ | 5/32 x 1⅛ | ½ | 113 |
| 1004 | 4 x 5 | 5/32 x 1⅛ | ½ | 126 |

Also made with drawn steel separable thimble

No. 4910 Pin with Strap for Wood Cross-Arm

## Hubbard Wood Top Pins with Steel Bolts

Bolts Hot Galvanized or Plain



No. 8078

Hubbard Wood Top Pins are composed of seasoned locust tops, thoroughly impregnated with paraffin and stiff steel fin bolts. They are made in a variety of heights with short and long shanks for wood, angle or channel steel arms, and for two sizes of insulator pin holes, 1 and 1⅜ inches in diameter.

No. 8070

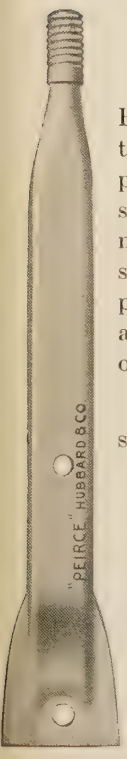
| Stock No. | Size of Wood Top, In. Diam. Top | Diam. Bottom | Length | Size of Bolt, In. Diam. | Length | Length of Bolt below Top, In. | Per 100 Weight Lbs. |
|---|---|---|---|---|---|---|---|
| 8070 | 1 | 1⅞ | 4½ | ½ | 5½ | 1 | 52 |
| 8071 | 1 | 2¼ | 5¼ | ½ | 6½ | 1¼ | 60 |
| 8072 | 1⅜ | 2¼ | 4½ | ⅝ | 5½ | 1 | 90 |
| 8073 | 1⅜ | 2¼ | 5¼ | ⅝ | 6½ | ¼ | 115 |
| 8074 | 1 | 1⅞ | 4½ | ½ | 9½ | 5 | 72 |
| 8075 | 1 | 2¼ | 5¼ | ½ | 10½ | 5¼ | 80 |
| 8076 | 1 | 2¼ | 5¼ | ½ | 11½ | 6¼ | 88 |
| 8077 | 1⅜ | 2¼ | 4½ | ⅝ | 9½ | 5 | 135 |
| 8078 | 1⅜ | 2¼ | 4½ | ⅝ | 10½ | 6 | 160 |
| 8079 | 1⅜ | 2¼ | 5¼ | ⅝ | 10½ | 5¼ | 165 |
| 8080 | 1⅜ | 2¼ | 6½ | ⅝ | 12½ | 6 | 190 |
| 8081 | 1⅜ | 2½ | 8 | ⅝ | 14 | 6 | 225 |
| 8082 | 1⅜ | 2¾ | 9 | ⅝ | 16 | 7 | 250 |

## Peirce

B&K
Forged Steel
Pin
with impregnated
wood top

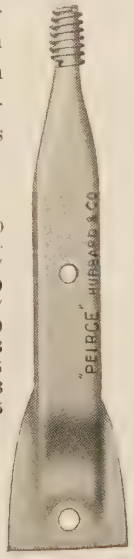
No. 1040

## Presteel Pins



No. 3040

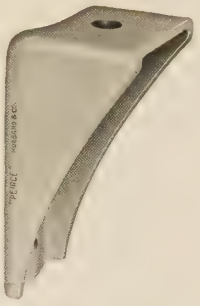
The strength, light weight and low cost of the Presteel Pins have brought about their use on all but the heaviest of high tension construction. They are pressed from sheet steel, which gives the maximum strength for a given weight, and are furnished with Peirce Spring Threads, which screw into insulators with 1 and 1⅜-inch pin holes, and with Peirce drawn steel separable thimbles for cementing into insulators of these two sizes.



No. 3048

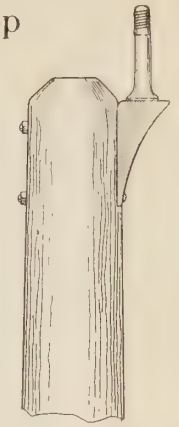
| Stock No. | Gauge Sheet Steel | Length | Spacing Between Holes | | Style of Top | Per 100 Wt., lbs. |
|---|---|---|---|---|---|---|
| 3040 | 10 | 18 | 8 | 1″ | Spring Thread | 227 |
| 3041 | 10 | 18 | 8 | 1 ⅜″ | Spring Thread | 230 |
| 3042 | 10 | 18 | 8 | 27/32″ | Thimble | 227 |
| 3043 | 10 | 18 | 8 | 1 7/32″ | Thimble | 230 |
| 3045 | 10 | 24 | 8 | 1″ | Spring Thread | 303 |
| 3046 | 10 | 24 | 8 | 1 ⅜″ | Spring Thread | 305 |
| 3047 | 10 | 24 | 8 | 27/32″ | Thimble | 303 |
| 3048 | 10 | 24 | 8 | 1 7/32″ | Thimble | 305 |

## Peirce Presteel Pole Top Brackets

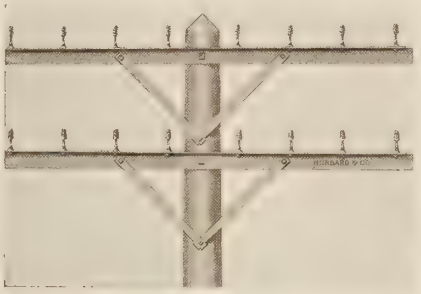


No. 3035
Pole Top Bracket

When wood or straight steel arms are used for a high tension line, the top wire of the triangle may be strung on a Peirce Forged Steel Pin mounted at the top of pole on this Pole Top Bracket.



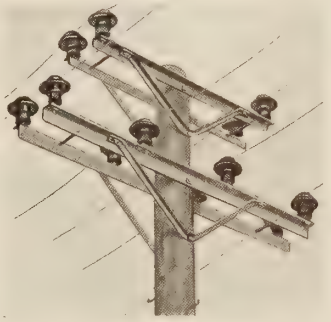
## Hubbard Steel Angle and Channel Cross-Arms—For Heavy Duty



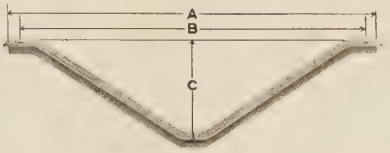
For dead ends, corners, and any situation or place where extra strength is required.

These arms can be furnished in any dimension and for any spacing.

## Hubbard Angle Cross-Arm Braces



In the construction of heavy pole lines, particularly for high voltage circuits, a one-piece cross-arm brace made of angle steel is in general use. The Angle, or Drop Brace, as it is sometimes called, gives greater strength and rigidity to the arm than can be secured with standard flat braces. It is fastened to the arm by a carriage bolt at each end, and to the pole by a lag screw.

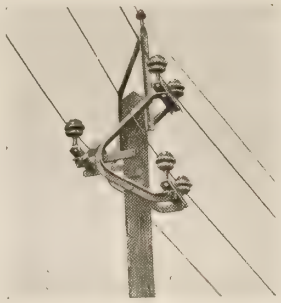



Braces of any desired dimensions can be furnished, and in ordering special sizes, please give the dimensions A, B and C, as indicated in the illustration, and state size of holes and size of angle desired.

## Bo-Arrow Arms

HIGH TENSION

SINGLE ARM



DOUBLE OR CORNER ARM

## Single Bo-Arrow Arms

A Bo-Arrow Arm consists of one Bow, one Arrow and one ¾ x 1½-inch machine bolt for fastening the Bow and Arrow together.

| Stock Number Type A | Stock Number Type B | Dimensions in Inches Wire Spacing | Dimensions in Inches Size Angle | Weight, Lbs. Each |
|---|---|---|---|---|
| 6024 | 6124 | 24 | 2½x2½x¼ | 21 |
| 6030 | 6130 | 30 | 2½x2½x¼ | 25 |
| 6036 | 6136 | 36 | 3 x3 x¼ | 39 |
| 6052 | 6152 | 52 | 3 x3 x¼ | 52 |
| 6072 | 6172 | 72 | 3 x3 x¼ | 69 |

## Bo-Arrow Double Arming Sets

These Sets are adjustable by means of the slots in the cross pieces for poles of from 7 to 11 inches in top diameter, and consist of a right- and a left-hand Bow, a right- and a left-hand straight Arrow, three cross-pieces of angle or channel steel, depending on whether forged steel or clamp pins are used, two bolts for fastening Bows and Arrows together and six bolts for clamping the cross-pieces to the arms. These cross-pieces are necessary to give sufficient clearance between the two large high voltage insulators required in each line wire, but are not needed on the 24- and 30-inch arms, in which cases two Bows, two straight Arrows and a double arming or spreader bolt for fastening the four parts together are furnished.

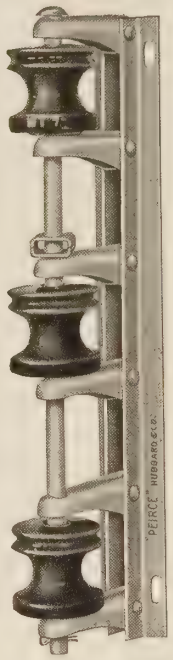
| Stock Number Type A | Stock Number Type B | Dimensions in Inches Wire Spacing | Dimensions in Inches Size Angle | Weight, Lbs. Per Set |
|---|---|---|---|---|
| 6224 | 6324 | 24 | 2½x2½x¼ | 43 |
| 6230 | 6330 | 30 | 2½x2½x¼ | 51 |
| 6236 | 6336 | 36 | 3 x3 x¼ | 113 |
| 6252 | 6352 | 52 | 3 x3 x¼ | 139 |
| 6272 | 6372 | 72 | 3 x3 x¼ | 173 |

Through Bolts are not included with Bo-Arrow Arms and Bayonets on account of the great variation in the lengths required for the different classes of poles used. Three bolts are needed for a Single or Double Arming Set and two for a Corner Bayonet, the proper size being about 2 inches longer than the top diameter of the pole. When bayonets are used with single arms, two washers are required per arm; without bayonets, three washers. No washers are needed with double arming sets or corner bayonets.

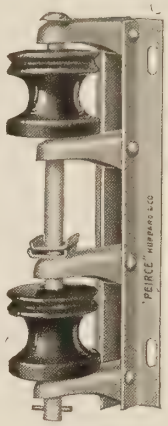
## Determination of Wire Spacing

The proper wire spacing for a given voltage depends on so many local conditions that it is impossible to determine it properly without detail information. Roughly, 24-inch is the usual spacing for 6,600 volt lines, 36-inch for voltages of 11,000, 22,000 and 33,000, 52-inch for 44,000 and 72-inch for 66,000 volts. There is a very marked tendency toward the use of a liberal wire spacing and many companies are now using much larger spacings than they formerly considered adequate, especially for 11,000 and 22,000 volt lines.

## Peirce Presteel Racks for Vertical Secondaries




No. 358




No. 258

Racks with 8-inch spacing between line wires.

No. 350

No. 250

Standard Racks with 4-inch spacing between line wires.

Vertical arrangement of the wires of Secondary Mains as provided by Peirce Secondary Racks attached to poles in place of Secondary Cross-Arms has won its way by sheer merit.

Fully 50% of secondary construction during 1919 employed this method.

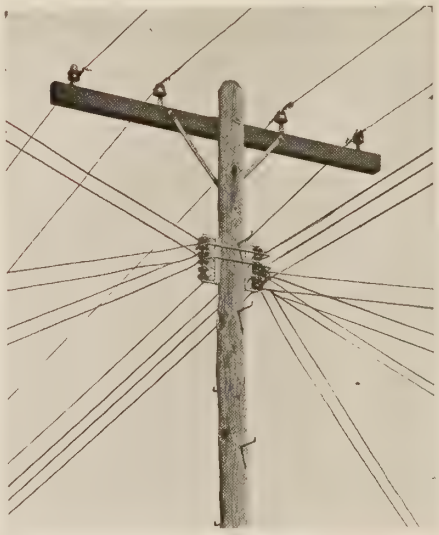
It is cheaper in first cost.

It can be maintained at ¼ the cost of cross-arm construction.

Wood arms are at their highest efficiency the day they are put up. From that day they rapidly decline. The PEIRCE SECONDARY RACK will last a lifetime.

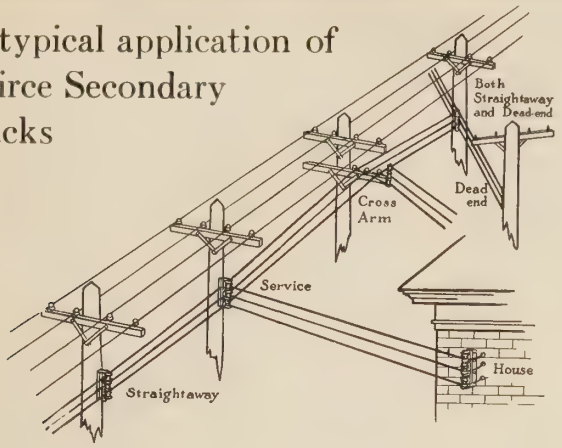
It reduces hazard. It eliminates inductive drop.

By its use cut-ins and cut-outs may be made at a minimum of time and expense.

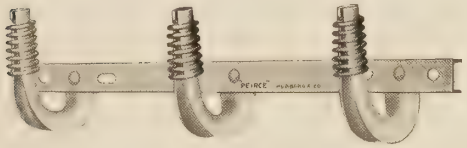


Latest Method of Low Tension Distribution

## A typical application of Peirce Secondary Racks

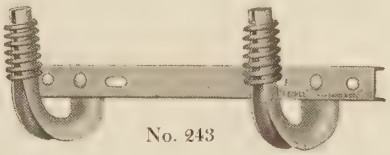



## Peirce Presteel Horizontal House Brackets



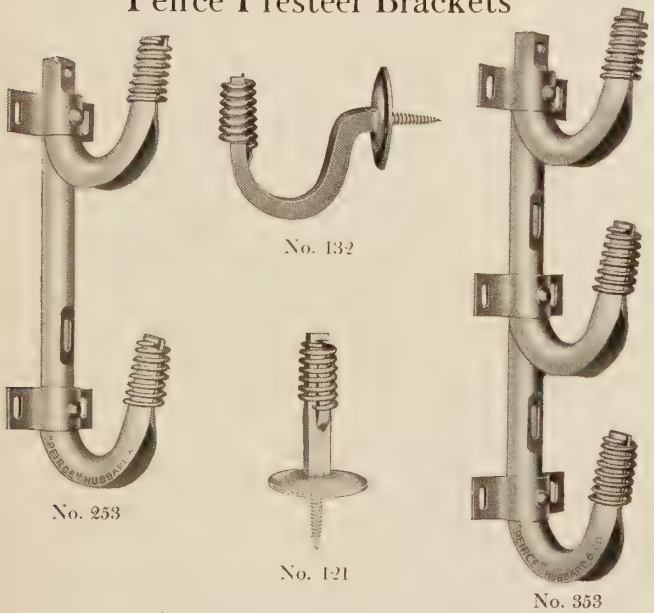
No. 343

Some engineers prefer a horizontal to a vertical house bracket. They have the same strength as the No. 253 Vertical Bracket, which six years' experience has shown is strong enough for all but the heaviest service wires.



No. 243

## Peirce Presteel Brackets



No. 253

No. 132

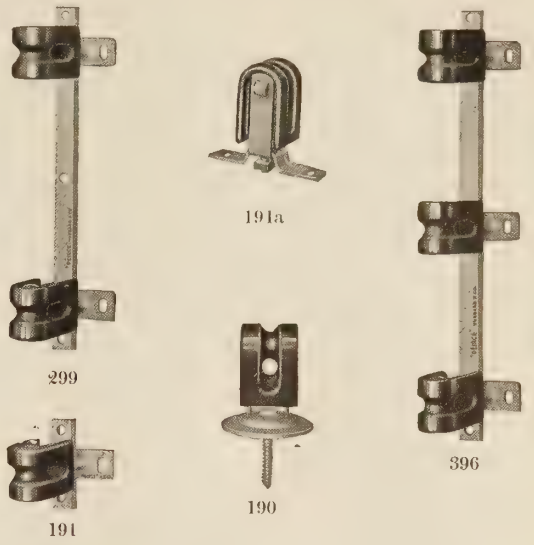
No. 121

No. 353

These brackets are more than twice as strong as the ordinary malleable iron brackets under any kind of loading—vertical, horizontal or side stress. They are suitable for service wires up to and including No. 6 in any reasonable length span.

For larger sizes of conductor and exceptional span, these brackets can be furnished in a heavier type.

## Peirce Wireholders



299

191a

396

191

190

Peirce Wireholders come completely assembled with insulators; packed in wooden boxes with insulators protected by corrugated fiber sleeves. They get to the job with minimum labor and absolutely no breakage.

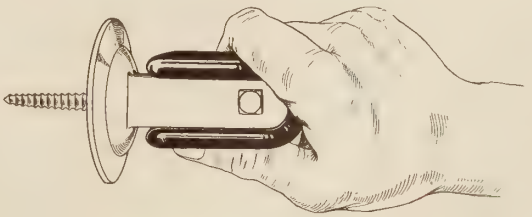
Their first cost is less than that of any other form of wall bracket.

Peirce Wireholders, being universal in their application, require a smaller stock in your storeroom.

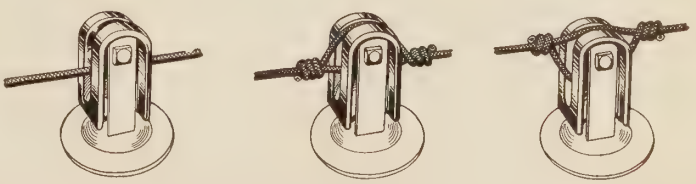
They largely eliminate tie wires, thus saving both labor and material.

You can't afford not to take advantage of these savings.

## The Peirce One-Ninety Wireholder Fits the Hand Like a Screwdriver



No Tools Required. A Jab— A Few Turns and It's In!



For most work, no tie wires are required. The line is simply run through the hole in the insulator.

Or line wire may be run through hole in insulator and tie wire placed in outer groove.

Or line wire may be placed in outer groove and tie wire run through the hole—desirable when long runs are made.

Ask Pettingell-Andrews Company for a catalog showing the complete line of Hubbard Pole Line Hardware and Peirce Construction Specialties.

# O-B HI-TENSION PORCELAIN INSULATORS

THE economic importance of the insulator on a transmission line is too often overlooked until after the system is put in operation. Although the cost of the insulators is only a small portion of the total investment, a single failure may interrupt service and affect the earnings of the entire system.

There are many systems where the loss from a few interruptions only will amount to more than the cost of the insulators on the entire line.

Most transmission companies recognize this, and The Ohio Brass Company has spent much time and money investigating operating conditions, so that improvements could be made in the insulators to give the best possible returns for the cost. Not only have designs been improved, but also manufacturing methods; while at the same time a most careful inspection and means of testing have been adopted with a view of eliminating line trouble just as far as possible. Inspection is carried on at the various stages by a corps of carefully trained men, the inspection being particularly rigid on the ware as it comes from the kilns.

O-B Hi-Tension Insulator Factory at Barberton, Ohio
(Main Office at Mansfield, Ohio)

After the ware has been inspected on delivery from the kilns it undergoes the electrical tests. On all pin type designs, the tests are so run, that the parts and the assembled insulator receive a super-spark stress. This test is carried on for at least two minutes, and weeds out material that a test at just below flashing voltage could never get. This test will in no way damage good material, but if manufacturing conditions are not properly developed, will result in prohibitive losses.

The electrical characteristics of the apparatus are such as to combine to a large extent the advantages of normal frequency, oscillator and the impact method. This effect is obtained by properly balanced characteristics in the testing apparatus.

In the case of many O–B designs, including all types of suspension insulators, additional routine electrical tests are provided to measure and eliminate any pieces having the least possible leakage through the material. The greater part of the slightly porous material can not be detected or eliminated by a normal or high frequency test, but may be detected and eliminated by these additional tests. Systematic work in the manufacturing processes produces insulators which show exceedingly small losses on O–B electrical tests, although they are the most severe in practice.

## Cementing

In general, the assembly of multipart insulators has not been given the attention it deserves. This, as well as the design, is of the utmost importance, for if not properly carried out, many of the insulators are sure to crack after several years' service, necessitating a reinsulation of the system.

Line trouble which has been attributed to electrical disturbances is in many cases actually due to insulators which have cracked. Trouble from this source has even been greater than that from porous material. This cracking is due largely to stresses set up through uneven temperature in the insulator, aggravated in some instances by stress due to cement expansion or by the internal stress in the material itself, caused by improper cooling. Much can be done to eliminate this through a good body composition and proper cooling in the kilns, but it is recognized that the maximum stress developed when the insulator is suddenly cooled, as in a rain shower, may be sufficient to destroy an otherwise perfect part.

Under operating conditions, the porcelain in an insulator, even in cases where there is no metal or cement present, is likely to work under a very narrow margin of safety for the maximum stress set up where one side of the insulator is hot and the other side cool.

The larger the insulator the more difficult it becomes to keep the stress down and there are many cases in practice where large heavy insulators have failed from cracking in much less time than smaller lighter insulators. It is a fairly easy matter

to relieve stress in the insulator, providing mechanical reliability is sacrificed. This, however, is not possible in a modern line as the hazard is entirely too great.

Fortunately, a method has been developed which not only provides an elastic joint and thereby keeps down a dangerous stress, but furthermore this joint is such that the mechanical reliability is greatly increased. To secure this result, a coated sanded surface is provided on the porcelain, the bearing coming on the tips of the sand grains. These sand grains, having a very much reduced area as compared to the porcelain body to which they are attached, take up practically all of the distortion, thereby removing the main body from serious stress.

This improvement is the most important of any which has been applied to insulators within recent years, and is worth all the time and expense required for its development, as it greatly increases the life or reliability of the insulator.

Up to the present time, this has been the only practical way developed of reducing the stresses which tend to crack an insulator under operating conditions and at the same time which does not sacrifice the very essential mechanical reliability.

## Suspension Insulators

Suspension insulators are assembled by The Ohio Brass Company under conditions of temperature and humidity such that the hydration of the cement is very complete. The bonding of the metal to the porcelain being accomplished at a high temperature tends to prevent undue stress in the porcelain on hot days, as the difference between the operating temperature and the assembly temperature is very small compared to what it would be if the assembly had been carried on at normal or low temperature.

Owing to the greater expansion rate of the metal over the porcelain, the assembly at higher temperature tends to place the porcelain in compression at normal working temperatures. This condition is particularly favorable, as porcelain is many times stronger in compression than in tension or shear.

To assemble properly at high temperature requires a very complete equipment, otherwise the results are doubtful and likely to be unsatisfactory.

## Rating

When requesting recommendations for insulator service, give accurate information regarding maximum working voltage, climatic conditions, geographic location, length of line, size of conductor, and amount of power on the system.

An insulator which might be entirely suitable for one locality may be entirely too small for another locality, as fogs, salt deposits, prevalence of heavy rains or thunder storms might cause too many interruptions to service through the spilling of the insulator.

## Commercial Insulator Tests

In Fig. 1 is shown the method of testing an assembled insulator, Fig. 2, that of testing a part and Fig. 3, that of testing a wall bushing. There are, of course, many pieces which do not come directly under these classes, but the tests are so applied as to be effective in weeding out material which might break down under service conditions.

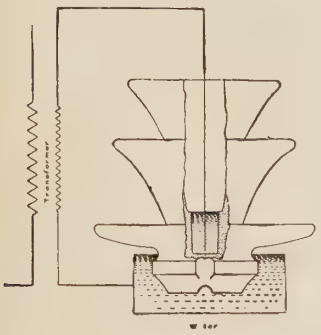


Figure 1

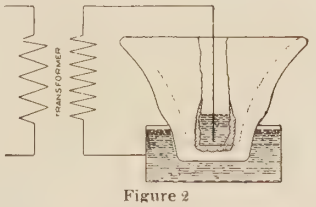



Figure 2

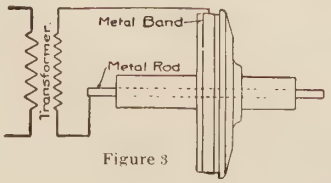



Figure 3

With but very few exceptions, all pieces are tested to at least a flashover stress for two minutes. The O–B testing equipment is very complete, including transformers which will give 400 K. V. to ground, oscillators and high voltage leakage or megger equipment.

A spark gap, with needle points whose distance apart is accurately adjustable, is kept on the high voltage leads of our testing set as a continual check on the accuracy of the measurements as made with the volt-meter on the primary circuit.

## Leakage Distance

The leakage distance, as given in the list for each insulator, is obtained by measuring the insulator or drawing as indicated by the line D shown in Fig. 5.

As the surface resistance varies directly as the length of the path and inversely as the width, it is evident that the length of leakage path alone does not represent the surface resistance of an insulator, for the width of the path varies with the diameter, and is only uniform throughout the length in the case of a tube or cylinder.

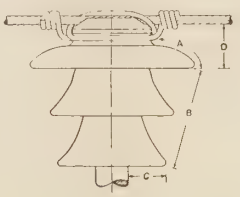



Figure 4

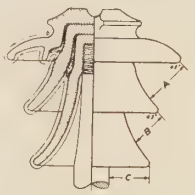



Figure 5

An insulator which has apparently a very small length of leakage path may be much more effective in preventing surface leakage than one having a much greater length of leakage path, if the design is such as to properly distribute the material, so as to keep surface stress down to a minimum.

As the distribution of material is very important in giving an insulator a high surface resistance, O–B methods of manufacture are developed along lines which insure proper shape in the parts.

## Arcing Distances of Insulators

The voltage value necessary to cause an insulator to arc from the tie wire to the pin can be closely approximated by measuring the insulator or a drawing as indicated in Figs. 4 or 5 and referring to the A. I. E. E. Standard Spark Gap table. Actual tests will give slightly different results according to conditions, but by following out this scheme fairly conservative estimates may be made upon the arcing voltage.

In Fig. 4 the sum of distances (A or D) +B +C gives the dry arcing distance, A or D being used depending upon which gives the shortest distance between the conductor and the lower edge of the top shell. In Fig. 5 the sum of A+B +C gives the arcing distance wet with the precipitation at 45 degrees with the vertical.

## Standard Insulator Threads

The standard threading for both pins and pin holes is four threads per inch.

Standard diameters for pin holes are 1 inch and 1⅜ inches. These dimensions are the extreme diameters at top of pin and at small end of pin hole.

Standard taper for pins and pin holes is 1-16 inch increase in diameter per inch of length.

## Glazes

Brown glaze has been adopted as standard. Other colors can be furnished on special order.

# O-B Pin Type Porcelain Insulators

No. 9400

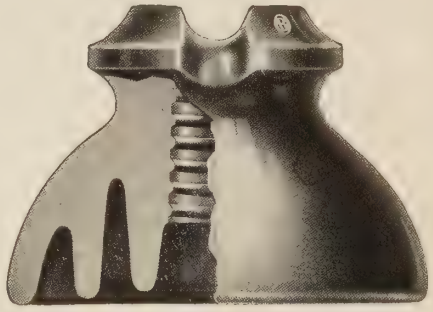
No. 10565

No. 10387—4000 Volts

No. 9403—6600 Volts

No. 9404—6600 Volts

Nos. 9890-11913—11,000 Volts



No. 10044—13,000 Volts

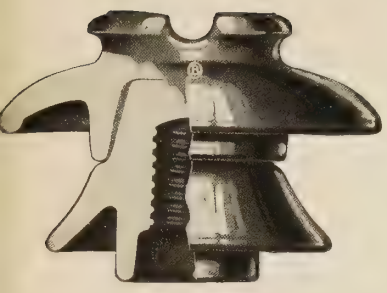
Nos. 12849-12850—17,000 Volts

Nos. 12851-12852—23,000 Volts

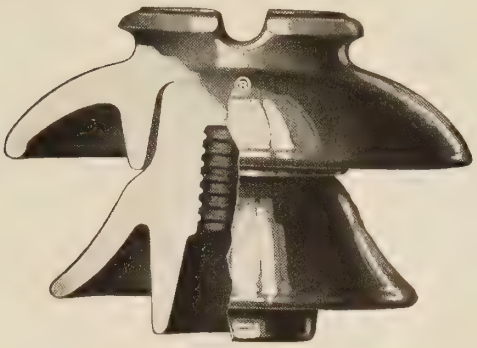
| Number | 9400 | 10565 | 10387 | 9403 | 9404 | 9890 | 11913 | 10044 | 12849 | 12850 | 12851 | 12852 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *General Rating, Volts | | | 4,000 | 6,600 | 6,600 | 11,000 | 11,000 | 13,000 | 17,000 | 17,000 | 23,000 | 23,000 |
| Height, inches | 2 15/16 | 3 3/8 | 3 | 3 | 3 | 4 1/4 | 4 5/16 | 3 1/4 | 4 | 4 | 4 1/2 | 4 1/2 |
| Diameter overall, inches | 2 5/16 | 2 5/8 | 3 1/4 | 3 3/4 | 3 3/4 | 4 1/4 | 4 3/8 | 4 5/8 | 5 1/2 | 5 1/2 | 7 | 7 |
| Size pin hole, inches | 1 | 1 | 1 | 1 | 1 | 1 3/8 | 1 | 1 | 1 | 1 3/8 | 1 | 1 3/8 |
| Test Voltage | | | | | | 40,000 | 40,000 | 50,000 | 60,000 | 60,000 | 60,000 | 60,000 |
| Leakage Surface, inches | | | 3 1/2 | 5 1/4 | 5 | 4 1/4 | 4 1/4 | 8 | 9 1/4 | 9 1/4 | 11 3/4 | 11 3/4 |
| Arcing Distance, Wet, inches | | | 3/4 | 1 1/4 | 1 1/4 | 1 1/2 | 1 1/2 | 1 5/8 | 2 1/4 | 2 1/4 | 2 7/8 | 2 7/8 |
| Minimum Length Pin, inches | | | | | | 4 | 4 | 4 | 4 | 4 | 5 | 5 |
| Approximate Net Weight per 100, lbs. | 56 | 81 | 86 | 125 | 111 | 281 | 281 | 213 | 338 | 332 | 500 | 500 |
| Approximate Weight Packed per 100, lbs. | 63 | 92 | 100 | 142 | 128 | 320 | 320 | 244 | 373 | 367 | 600 | 600 |
| Approximate Number in Package | 550 | 355 | 300 | 230 | 230 | 100 | 100 | 125 | 75 | 75 | 40 | 40 |

*See "Rating" on page 55

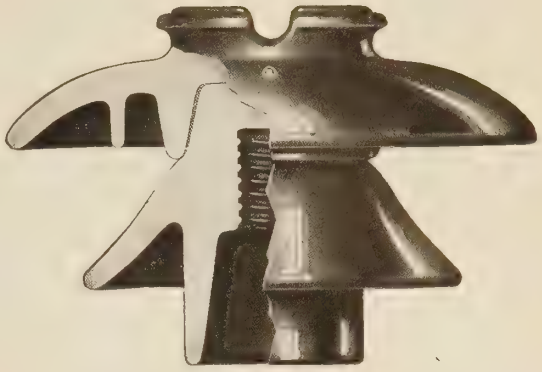
# O-B Pin Type Porcelain Insulators



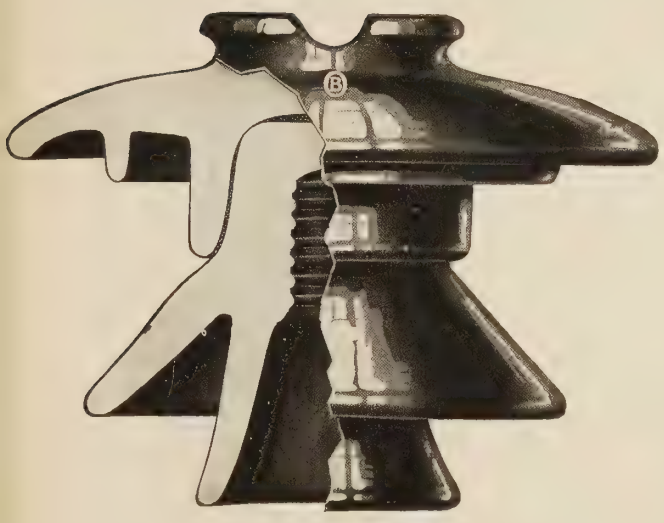
No. 12546—27,000 Volts



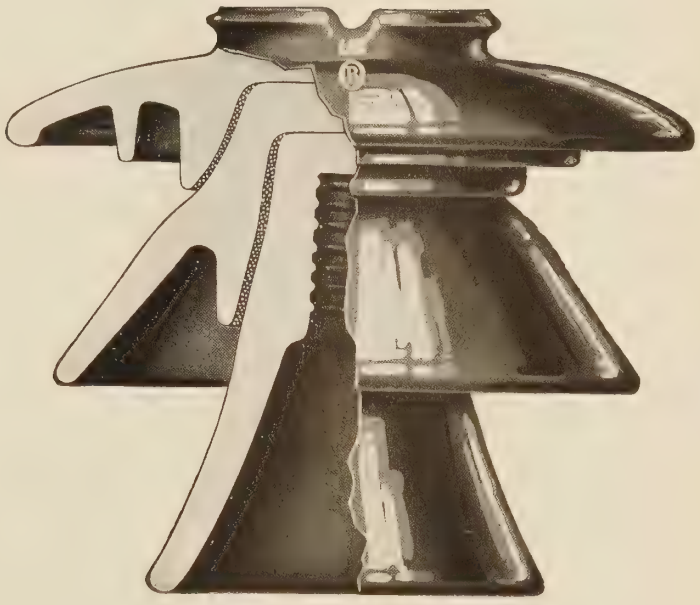
No. 11622—35,000 Volts



No. 11623—45,000 Volts



No. 12855—55,000 Volts



No. 12552—66,000 Volts

| Number | 12546 | 11622 | 11623 | 12855 | 12552 |
|---|---|---|---|---|---|
| *General Rating, Volts | 27,000 | 35,000 | 45,000 | 55,000 | 66,000 |
| Height, inches | 5¼ | 6⅛ | 7 | 9 | 11⅛ |
| Diameter overall, inches | 7½ | 9 | 10½ | 12 | 13 |
| Size pin hole, inches | 1⅜ | 1⅜ | 1⅜ | 1⅜ | 1⅜ |
| Test Voltage | 100,000 | 125,000 | 145,000 | 175,000 | 190,000 |
| Leakage Surface, inches | 11⅞ | 17 | 21¼ | 25¾ | 34¼ |
| Arcing Distance, Wet, inches | 4⅜ | 5¾ | 7 | 8¼ | 9½ |
| Minimum Length Pin, inches | 6 | 6 | 7½ | 9 | 11½ |
| Approximate Net Weight per 100, lbs. | 620 | 925 | 1140 | 1600 | 3200 |
| Approximate Weight Packed per 100, lbs. | 876 | 1350 | 1700 | 3000 | 4070 |
| Approximate Number in Package | 6 | 6 | 6 | 3 | 3 |

*See "Rating" on Page 55

# O-B Suspension Porcelain Insulators

(Patented)

The O–B Suspension Insulator contains many refinements not found in other insulators of this type. It consists of a one-piece porcelain disc with concentric circular ribs or petticoats on the under surface, a galvanized cap casting which is securely cemented to the projecting head of the porcelain disc, and a galvanized steel center pin cemented in a pin hole which extends well into the head of the porcelain disc.

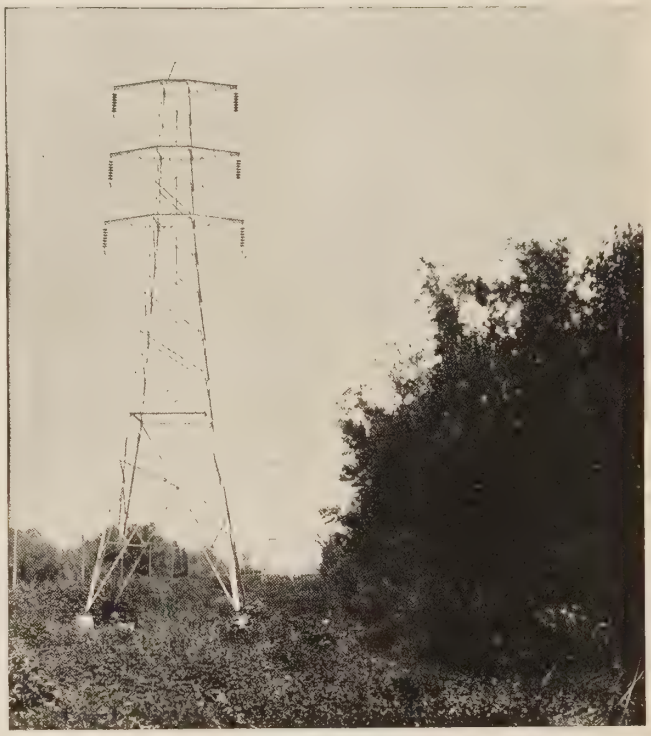
In this design, as in all O–B high-efficiency design Insulators, the electrical and mechanical characteristics are properly balanced. There is maximum insulation, reliability and mechanical strength for the length and weight of the Insulator.

The Insulator may consist of one or of several Units, the number depending upon line voltage, local conditions, and the factor of safety or reliability desired by the user. If, when the line is erected, a future increase in voltage is contemplated, it is particularly advantageous to install Suspension Insulators as additional Units can be added at any time.

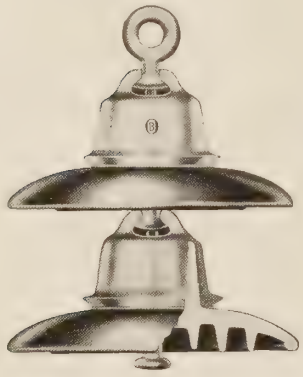
On Type B Insulators, an efficient and convenient connection between Units is made by the patented ball and socket joint. Each Insulator Unit is an exact duplicate of the others.

Type D Insulators have the clevis connection between units. All dimensions are in accordance with the standards adopted by the insulator manufacturers.

Diameters of all insulators shown below, 10 inches. All metal parts are galvanized.

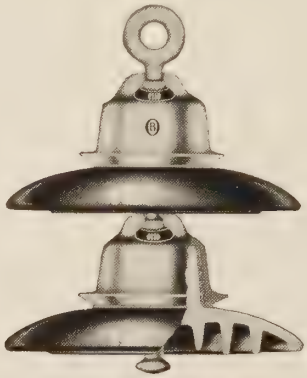


Type B, Form 1—Patented



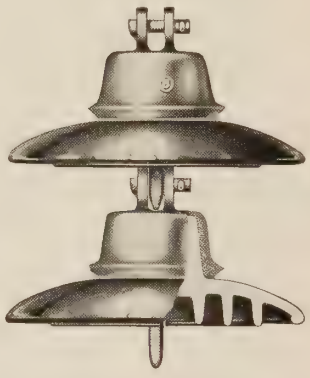
Two Units No. 25620 connected; lower unit partly sectioned

Type B, Form 2—Patented



Two Units No. 25622 connected; lower unit partly sectioned

Type D, Form 3—Patented



Two Units No. 25623 connected; lower unit partly sectioned

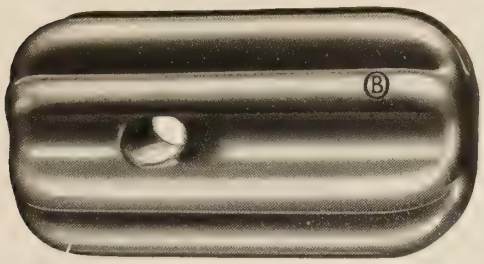
| Number of Units | Length Complete Inches | Weight Complete Lbs. | Weight Complete Packed, lbs. |
|---|---|---|---|
| 1 | 5 | 10 | 18 |
| 2 | 10 | 20 | 28 |
| 3 | 15 | 30 | 38 |
| 4 | 20 | 40 | 48 |
| 5 | 25 | 50 | 59 |
| 6 | 30 | 59 | 69 |
| 7 | 35 | 69 | 80 |
| 8 | 40 | 79 | 90 |
| 9 | 45 | 89 | 99 |
| 10 | 50 | 99 | 110 |

| Number of Units | Length Complete Inches | Weight Complete Lbs. | Weight Complete Packed, lbs. |
|---|---|---|---|
| 1 | 4¾ | 9 | 18 |
| 2 | 9½ | 18 | 26 |
| 3 | 14¼ | 27 | 36 |
| 4 | 19 | 36 | 45 |
| 5 | 23¾ | 46 | 55 |
| 6 | 28½ | 55 | 65 |
| 7 | 33¼ | 64 | 74 |
| 8 | 38 | 73 | 84 |
| 9 | 42¾ | 82 | 94 |
| 10 | 47½ | 91 | 103 |

| Number of Units | Length Complete Inches | Weight Complete Lbs. | Weight Complete Packed, lbs. |
|---|---|---|---|
| 1 | 5⅜ | 9 | 18 |
| 2 | 10¾ | 18 | 26 |
| 3 | 16⅛ | 27 | 36 |
| 4 | 21½ | 36 | 45 |
| 5 | 26⅞ | 46 | 55 |
| 6 | 32¼ | 55 | 65 |
| 7 | 37⅝ | 64 | 74 |
| 8 | 43 | 73 | 84 |
| 9 | 48⅜ | 82 | 94 |
| 10 | 53¾ | 91 | 103 |

# O-B Porcelain Strain Insulators

Multi-Fin—6600 Volts



No. 25314

A sturdy design particularly suited to heavy work. Ultimate strength is in excess of 20,000 pounds. See data below.

Type XH—Patent Applied for—1500 Volts

No. 25009

A rugged Insulator for guy wires and dead ends. Has long leakage path and is made of high tension porcelain (wet-ware).

Rounded corners permit rough handling without breakage.

Strands are interlocked so they cannot become separated should Insulator be broken.

Holes for strand are straight, making installation easy.

Ultimate strength (tested with high strength steel strand) over 15,000 pounds. See data below.

Type X—Patented—1500, 3000, 6600 Volts

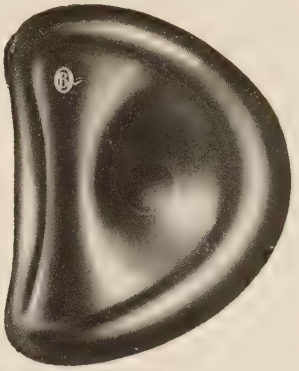
Nos. 12458—13431—11629—11630

Used for insulating guy wires and dead-ending. Has long leakage path and is made of high tension porcelain having high mechanical strength.

Strands are interlocked so that they cannot become separated should insulator be broken.

Holes for strand are straight, making installation easy. See data below:

Link—11,000 Volts



Front View—No. 11940

Back View—No. 11940

Used for insulating spans or dead-ending. Strand wire can easily be threaded as holes are practically straight.

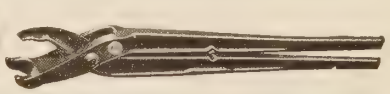
It is provided with a ball-edge which increases its ruggedness.

| | |
|---|---|
| Test Voltage | 70,000 |
| Maximum Working Load | 2,500 lbs. |
| Ultimate Strength | 8,000 lbs. |
| Diameter of Insulator | 7¾ inches |

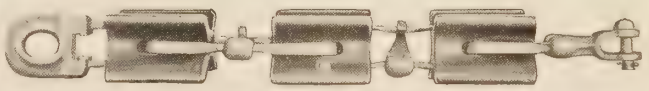
See other data below.

Type X—Insulator Fittings—Patented

Nos. 12841—12843



No. 13400



Nos. 12841—12843—12845

For installing any of the strain insulators on this page except Nos. 25314 and 11630

Use of fittings, with single Insulator or with several in series, gives a positive connection and permits easy renewal of damaged Insulators.

Bolts are provided with lead sleeve for bearing on porcelain.

Ultimate strength for the 5-16 inch bolts is 8,000 pounds; for the ⅜-inch bolt, 11,000 pounds. Larger bolts can be furnished to meet special conditions.

Strength of castings is greater than that of bolts.

Bolts are forged steel; castings, malleable iron, all sherardized.

Opening in clevis is 13-16 inch; diameter clevis bolt, ½ inch.

Eye in Nos. 12843 and 12844 is 1½ x 1¼ inch.

12841—End Bolt 5/16 inch Diameter, with Clevis
12842—End Bolt ⅜ inch Diameter, with Clevis
12843—End Bolt 5/16 inch Diameter, with Eye
12844—End Bolt ⅜ inch Diameter, with Eye
12845—Intermediate Bolt, 5/16 inch Diameter, with Casting
12846—Intermediate Bolt, ⅜ inch Diameter, with Casting

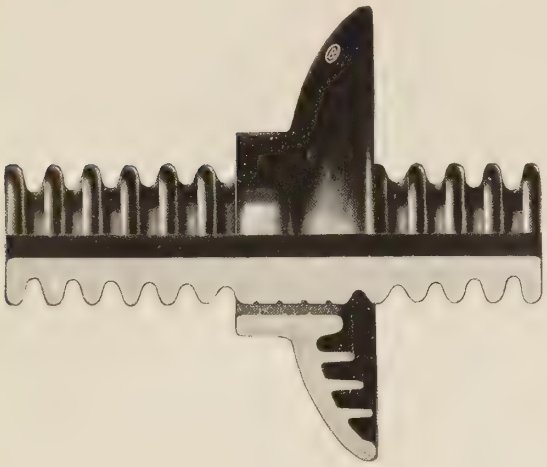
Sockets can be furnished for any size cable.

| Number | 25314 | 25009 | 12458 | 13431 | 11629 | 11630 | 11940 |
|---|---|---|---|---|---|---|---|
| *General Rating, Volts | 6600 | 1500 | 1500 | 1500 | 3000 | 6500 | 11000 |
| Diameter, inches | 4¼ | 3⅝ | 3½ | 3⅝ | 4⅜ | 5⅜ | 7¾ |
| Length, inches | 7 | 4 | 3½ | 4 | 5 | 6½ | |
| Diameter strand hole, inches | ¾ | 11/16 | ⅝ | 1 | ⅝ | ⅝ | 11/16 |
| Approximate Net Weight per 100, lbs. | 450 | 175 | 113 | 138 | 200 | 335 | 400 |
| Approximate Weight Packed per 100, lbs. | 490 | 185 | 123 | 178 | 250 | 410 | 565 |
| Approximate Number in Package | 70 | 240 | 260 | 260 | 100 | 50 | 30 |

*See "Rating" Page 55

## O-B Porcelain Wall Insulator

Type B, Form 1 — 30,000-60,000 Volts



This insulator consists of a corrugated porcelain disc cemented on a heavy corrugated porcelain tube. May be cemented in the wall or in a small housing built on the side of the wall. In any case the corrugated surface of flange should face towards the outside.

Similar designs with flanges up to 30 in. diameter may be furnished on special order.

| No. | *General Rating | Leakage Surface | Net Weight Each | Maximum Diameter | Length Overall |
|---|---|---|---|---|---|
| 10048 | 30000 | 19 in. | 22 lbs. | 12 in. | 14 in. |
| 10049 | 50000 | 21 in. | 24 lbs. | 14 in. | 14 in. |
| 10050 | 60000 | 30 in. | 29 lbs. | 14 in. | 20 in. |

* See "Rating" page 55.

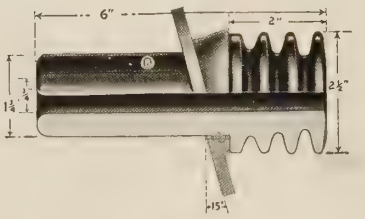
## Special O-B Porcelains

The photograph below conveys some idea of the capacity of the O–B factory for producing special shapes.

If you encounter special conditions take your problem up with O–B Engineers. They can help you to a solution.

## O-B Low Voltage Outlet Bushing

2300-6600 Volts

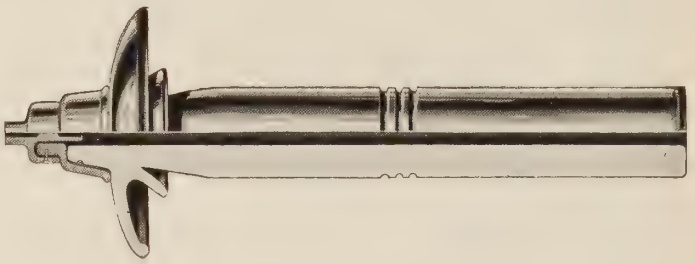



No. 13225

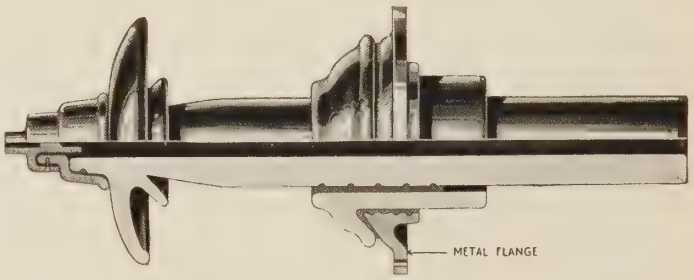
Especially adapted for primary meter house outlets, etc. Bushing is furnished complete with flange as shown.

Can be furnished in special lengths, either end or both.

## O-B Porcelain Wall or Roof Insulators

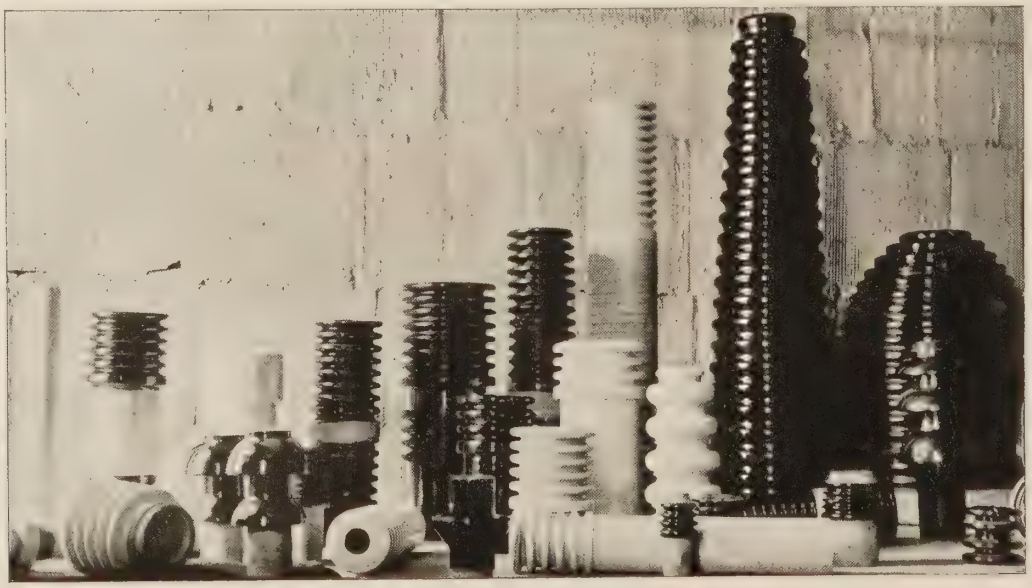


No. 10649—11,000 Volts
30 1/16 inches long, 11 inches maximum diameter




No. 10651—22,000 to 33,000 Volts
30 1/16 inches long. Diameter flange, 12 inches

The above insulators are typical O-B Wall or Roof Insulators. There are various standard designs to take care of voltages up to 100,000.

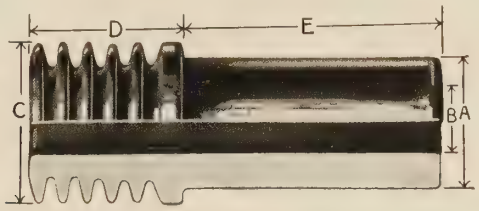


# O-B Porcelain Bushings and Tubes

Regularly furnished white glazed.

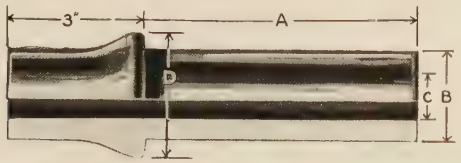
The actual working voltage, thickness of wall, floor, etc., and whether for indoor or outdoor service, should be specified on all orders or inquiries.

High Tension, Form 1



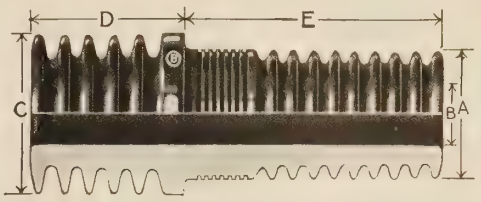

| Number | Dimensions in Inches | | | | | Test Voltage |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| 10880 | 3½ | 1¼ | 4 | 3 | 5 | 30,000 |
| 10881 | 3½ | 2 | 4 | 3 | 5 | 30,000 |
| 10882 | 4¼ | 1¼ | 5 | 3 | 5 | 30,000 |
| 10883 | 4¼ | 2 | 5 | 3 | 5 | 30,000 |
| 10884 | 5 | 3 | 5½ | 3 | 5 | 30,000 |
| 10885 | 5 | 1¼ | 5½ | 3 | 5 | 30,000 |
| 10886 | 5 | 2 | 5½ | 3 | 5 | 30,000 |
| 10887 | 3½ | 1¼ | 4 | 4 | 6 | 40,000 |
| 10888 | 3½ | 2 | 4 | 4 | 6 | 40,000 |
| 10889 | 4¼ | 1¼ | 5 | 4 | 6 | 40,000 |
| 10890 | 4¼ | 2 | 5 | 4 | 6 | 40,000 |
| 10891 | 5 | 3 | 5½ | 4 | 6 | 40,000 |
| 10892 | 5 | 1¼ | 5½ | 4 | 6 | 40,000 |
| 10893 | 5 | 2 | 5½ | 4 | 6 | 40,000 |
| 10894 | 3½ | 1¼ | 4 | 6 | 8 | 55,000 |
| 10895 | 3½ | 2 | 4 | 6 | 8 | 55,000 |
| 10896 | 4¼ | 1¼ | 5 | 6 | 8 | 55,000 |
| 10897 | 4¼ | 2 | 5 | 6 | 8 | 55,000 |
| 10898 | 5 | 3 | 5½ | 6 | 8 | 55,000 |
| 10899 | 5 | 1¼ | 5½ | 6 | 8 | 55,000 |
| 10900 | 5 | 2 | 5½ | 6 | 8 | 55,000 |
| 10901 | 3½ | 1¼ | 4 | 8 | 10 | 70,000 |
| 10902 | 4¼ | 1¼ | 5 | 8 | 10 | 70,000 |
| 10903 | 4¼ | 2 | 5 | 8 | 10 | 70,000 |
| 10904 | 5 | 1¼ | 5½ | 8 | 10 | 70,000 |
| 10905 | 5 | 2 | 5½ | 8 | 10 | 70,000 |
| 10906 | 5 | 3 | 5½ | 8 | 10 | 70,000 |
| 10907 | 4¼ | 1¼ | 5 | 10 | 12 | 85,000 |
| 10908 | 5 | 1¼ | 5½ | 10 | 12 | 85,000 |
| 10909 | 5 | 2 | 5½ | 10 | 12 | 85,000 |
| 10910 | 5 | 3 | 5½ | 10 | 12 | 85,000 |
| 10911 | 4¼ | 1¼ | 5 | 12 | 14 | 100,000 |
| 10912 | 5 | 1¼ | 5½ | 12 | 14 | 100,000 |
| 10913 | 5 | 2 | 5½ | 12 | 14 | 100,000 |

High Tension, Form 3



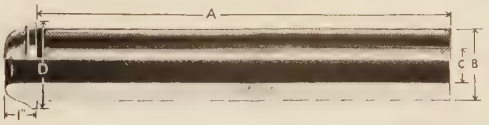

| Number | Dimensions in Inches | | | | Test Voltage |
|---|---|---|---|---|---|
| | A | B | C | D | |
| 12880 | 3 | 2 | 1 | 2¾ | 20,000 |
| 12881 | 3 | 2½ | 1½ | 3¼ | 20,000 |
| 12882 | 3 | 3 | 2 | 3¾ | 20,000 |
| 12883 | 5 | 2 | 1 | 2¾ | 30,000 |
| 12884 | 5 | 2½ | 1½ | 3¼ | 30,000 |
| 12885 | 5 | 3 | 2 | 3¾ | 30,000 |
| 12886 | 7 | 2 | 1 | 2¾ | 40,000 |
| 12887 | 7 | 2½ | 1½ | 3¼ | 40,000 |
| 12888 | 7 | 3 | 2 | 3¾ | 40,000 |
| 12889 | 9 | 2 | 1 | 2¾ | 50,000 |
| 12890 | 9 | 2½ | 1½ | 3¼ | 50,000 |
| 12891 | 9 | 3 | 2 | 3¾ | 50,000 |
| 12892 | 11 | 2 | 1 | 2¾ | 55,000 |
| 12893 | 11 | 2½ | 1½ | 3¼ | 55,000 |
| 12894 | 11 | 3 | 2 | 3¾ | 55,000 |
| 12895 | 13 | 2 | 1 | 2¾ | 60,000 |
| 12896 | 13 | 2½ | 1½ | 3¼ | 60,000 |
| 12897 | 13 | 3 | 2 | 3¾ | 60,000 |

High Tension, Form 2




| Number | Dimensions in Inches | | | | | Test Voltage |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| 10914 | 3½ | 1¼ | 4 | 3 | 5 | 30,000 |
| 10915 | 3½ | 2 | 4 | 3 | 5 | 30,000 |
| 10916 | 4¼ | 1¼ | 5 | 3 | 5 | 30,000 |
| 10917 | 4¼ | 2 | 5 | 3 | 5 | 30,000 |
| 10918 | 5 | 3 | 5½ | 3 | 5 | 30,000 |
| 10919 | 5 | 1¼ | 5½ | 3 | 5 | 30,000 |
| 10920 | 5 | 2 | 5½ | 3 | 5 | 30,000 |
| 10921 | 3½ | 1¼ | 4 | 4 | 6 | 40,000 |
| 10922 | 3½ | 2 | 4 | 4 | 6 | 40,000 |
| 10923 | 4¼ | 1¼ | 5 | 4 | 6 | 40,000 |
| 10924 | 4¼ | 2 | 5 | 4 | 6 | 40,000 |
| 10925 | 5 | 3 | 5½ | 4 | 6 | 40,000 |
| 10926 | 5 | 1¼ | 5½ | 4 | 6 | 40,000 |
| 10927 | 5 | 2 | 5½ | 4 | 6 | 40,000 |
| 10928 | 3½ | 1¼ | 4 | 6 | 8 | 55,000 |
| 10929 | 3½ | 2 | 4 | 6 | 8 | 55,000 |
| 10930 | 4¼ | 1¼ | 5 | 6 | 8 | 55,000 |
| 10931 | 4¼ | 2 | 5 | 6 | 8 | 55,000 |
| 10932 | 5 | 3 | 5½ | 6 | 8 | 55,000 |
| 10933 | 5 | 1¼ | 5½ | 6 | 8 | 55,000 |
| 10934 | 5 | 2 | 5½ | 6 | 8 | 55,000 |
| 10935 | 3½ | 1¼ | 4 | 8 | 10 | 70,000 |
| 10936 | 4¼ | 1¼ | 5 | 8 | 10 | 70,000 |
| 10937 | 4¼ | 2 | 5 | 8 | 10 | 70,000 |
| 10938 | 5 | 1¼ | 5½ | 8 | 10 | 70,000 |
| 10939 | 5 | 2 | 5½ | 8 | 10 | 70,000 |
| 10940 | 5 | 3 | 5½ | 8 | 10 | 70,000 |
| 10941 | 4¼ | 1¼ | 5 | 10 | 12 | 85,000 |
| 10942 | 5 | 1¼ | 5½ | 10 | 12 | 85,000 |
| 10943 | 5 | 2 | 5½ | 10 | 12 | 85,000 |
| 10944 | 5 | 3 | 5½ | 10 | 12 | 85,000 |
| 10945 | 4¼ | 1¼ | 5 | 12 | 14 | 100,000 |
| 10946 | 5 | 1¼ | 5½ | 12 | 14 | 100,000 |
| 10947 | 5 | 2 | 5½ | 12 | 14 | 100,000 |

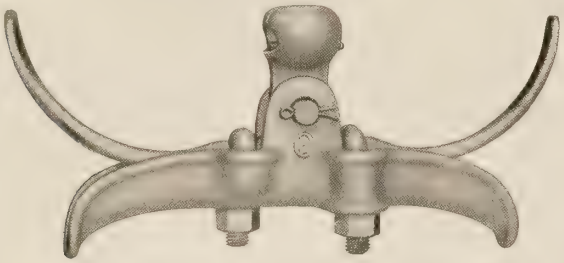
High Tension, Form 4




| Number | Dimensions in Inches | | | | Test Voltage |
|---|---|---|---|---|---|
| | A | B | C | D | |
| 12898 | 3 | 2 | 1 | 2½ | 10,000 |
| 12899 | 3 | 2½ | 1½ | 3 | 10,000 |
| 12900 | 5 | 2 | 1 | 2½ | 20,000 |
| 12901 | 5 | 2½ | 1½ | 3 | 20,000 |
| 12902 | 5 | 3 | 2 | 3½ | 20,000 |
| 12903 | 7 | 2 | 1 | 2½ | 30,000 |
| 12904 | 7 | 2½ | 1½ | 3 | 30,000 |
| 12905 | 7 | 3 | 2 | 3½ | 30,000 |
| 12906 | 9 | 2 | 1 | 2½ | 40,000 |
| 12907 | 9 | 2½ | 1½ | 3 | 40,000 |
| 12908 | 9 | 3 | 2 | 3½ | 40,000 |
| 12909 | 11 | 2 | 1 | 2½ | 50,000 |
| 12910 | 11 | 2½ | 1½ | 3 | 50,000 |
| 12911 | 11 | 3 | 2 | 3½ | 50,000 |
| 12912 | 13 | 2 | 1 | 2½ | 55,000 |
| 12913 | 13 | 2½ | 1½ | 3 | 55,000 |
| 12914 | 13 | 3 | 2 | 3½ | 55,000 |
| 12915 | 15 | 2 | 1 | 2½ | 60,000 |
| 12916 | 15 | 2½ | 1½ | 3 | 60,000 |
| 12917 | 15 | 3 | 2 | 3½ | 60,000 |
| 12918 | 17 | 2 | 1 | 2½ | 70,000 |
| 12919 | 17 | 2½ | 1½ | 3 | 70,000 |
| 12920 | 17 | 3 | 2 | 3½ | 70,000 |
| 12921 | 19 | 2 | 1 | 2½ | 75,000 |
| 12922 | 19 | 2½ | 1½ | 3 | 75,000 |
| 12923 | 19 | 3 | 2 | 3½ | 75,000 |

## O-B Suspension and Strain Wire Clamps

Furnished with or without discharge horns. Discharge horns are desirable under certain conditions, as they cut down the time lag for excessive surges and increase the factor of safety of the insulators. Castings are malleable iron, galvanized.



Type B, Form 1—Suspension Wire Clamp—Patented

Swivel connection between body of clamp and socket prevents severe bending strains on center pin of insulator which would otherwise be caused should the transmission wire break.

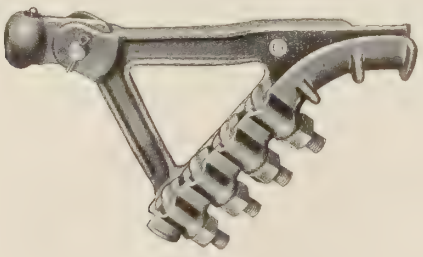
For use with Type B Suspension Insulators.

With Discharge Horns

| Number | *Diameter Copper Cable | | Weight Packed per 100 |
|---|---|---|---|
| | Minimum | Maximum | |
| 11549 | 3/16 in. | 7/16 in. | 504 lbs. |
| 11551 | 3/8 in. | 11/16 in. | 607 lbs. |
| 11644 | 5/8 in. | 1 in. | 840 lbs. |

Without Discharge Horns

| | | | |
|---|---|---|---|
| 11538 | 3/16 in. | 9/16 in. | 417 lbs. |
| 11540 | 5/16 in. | 11/16 in. | 524 lbs. |



No. 11542—Suspension Strain Wire Clamp—Patented

No loose parts need be handled in installing, as hook bolts can be turned back out of the way while wire is being seated in groove.

Without Discharge Horn

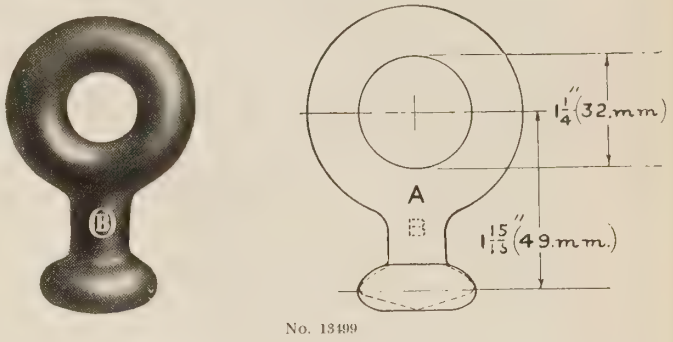
| Number | *Diameter Copper Cable | | Insulators Used With | Weight Packed Per 100 |
|---|---|---|---|---|
| | Minimum | Maximum | | |
| 11541 | 3/16 in. | 1/2 in. | Type B | 646 |
| 10755 | 3/16 in. | 1/2 in. | Type D | 540 |
| 11542 | 5/16 in. | 11/16 in. | Type B | 697 |
| 11040 | 5/16 in. | 11/16 in. | Type D | 591 |
| 11543 | 3/8 in. | 3/4 in. | Type B | 859 |
| 11328 | 3/8 in. | 3/4 in. | Type D | 753 |

With Discharge Horn

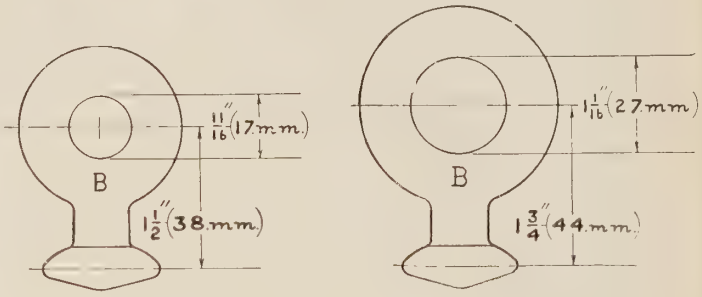
| | | | | |
|---|---|---|---|---|
| 11946 | 3/16 in. | 1/2 in. | Type B | 786 |
| 11947 | 3/16 in. | 1/2 in. | Type D | 680 |
| 11949 | 5/16 in. | 11/16 in. | Type B | 837 |
| 11950 | 5/16 in. | 11/16 in. | Type D | 751 |
| 11952 | 3/8 in. | 3/4 in. | Type B | 999 |
| 11953 | 3/8 in. | 3/4 in. | Type D | 893 |

* When aluminum cable is used, an aluminum protecting sleeve about 1/16 in. thick should encircle cable in clamp and diameter should be measured over sleeve.

## Suspension Eyes



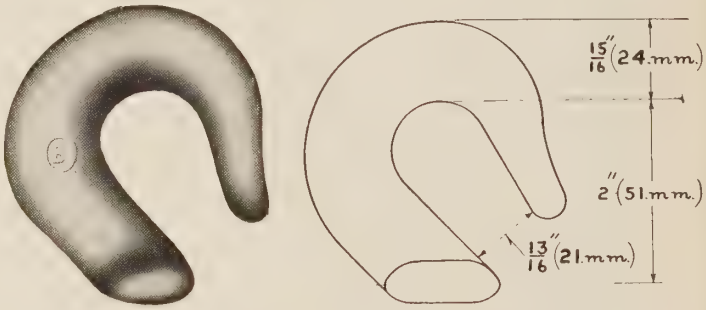

No. 13499



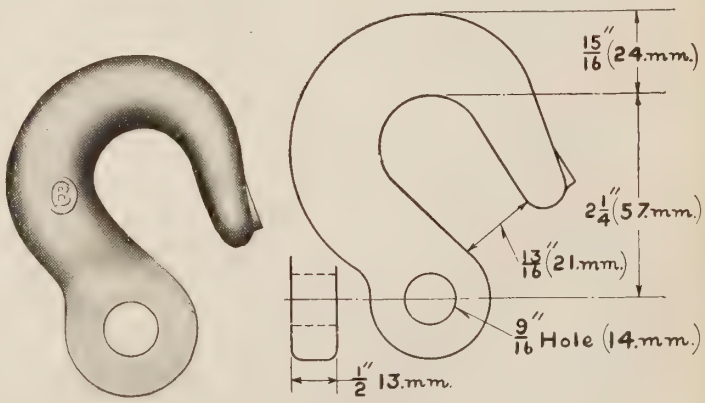

No. 11547 No. 12939

Used for attaching Type B Suspension Insulators to towers. Made of drop forged steel, galvanized.

## Suspension Hooks




No. 11546—For Type B Suspension Insulator—Malleable Iron
No. 13394—For Type B Suspension Insulator—Forged Steel




No. 13393—For Type D Suspension Insulator—Malleable Iron

This hook is used for attaching Suspension Insulators to towers. The opening of the hook is closed by the insulator cap, thus preventing unhooking after installation. Galvanized finish.

## Ball Socket Eye

No. 11544

For attaching Type B Suspension Insulators to Type E Strain Clamps or other clamps having a clevis. Weight, packed, 111 pounds per 100. 9-16 in. hole. Malleable iron, galvanized.

## Ball Socket Clevis

No. 11545—with ⅝ in. Bolt

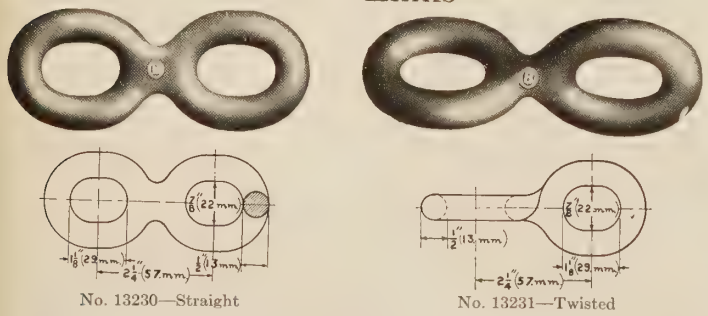
For attaching clamp having an eye to the ball center pin of Type B Suspension Insulators. Weight, packed, 145 pounds per 100. Malleable iron, galvanized.

## Suspension Clevis

No. 12937

For attaching Type B Suspension Insulators to towers. Weight, packed, 115 pounds per 100. Cast steel, galvanized.

## Strain Links

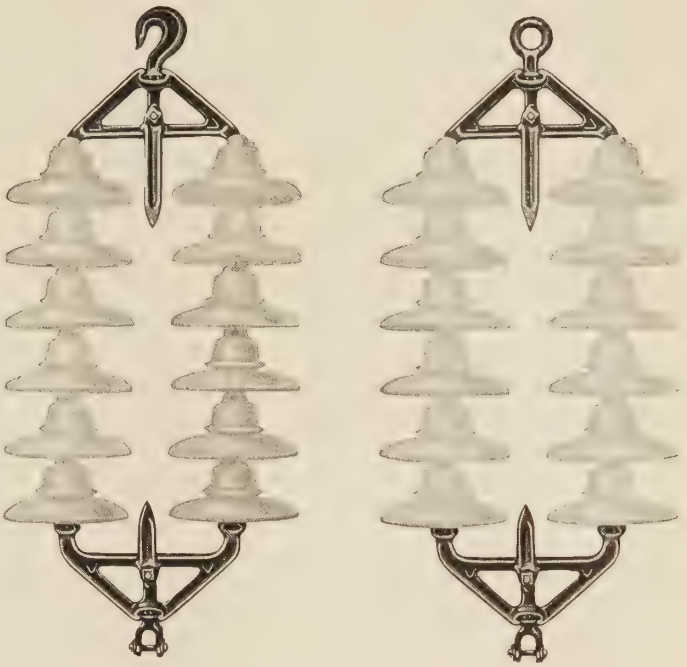



No. 13230—Straight  No. 13231—Twisted

Used for attaching Suspension Insulators to towers, strain yokes, etc. Made in one piece of drop forged steel, galvanized.

## Insulator Strain Yokes

Form 1—Patented



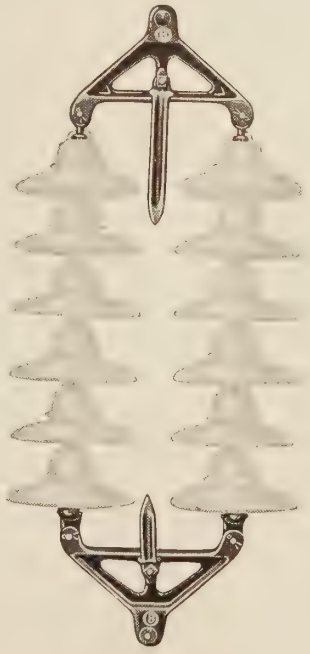
No. 11686—Upper Yoke
No. 11688—Lower Yoke

No. 12931—Upper Yoke
No. 11688—Lower Yoke

For particularly heavy strains at dead ends, etc., or for double construction at railway crossings, two strings of Type B Suspension Insulators may be connected in multiple by means of these yokes which are provided with discharge horns. Upper yokes furnished with clevis fitting at top, if desired.

Castings malleable iron, galvanized.

Form 2—Patented



No. 12933—Upper Yoke
No. 12935—Lower Yoke

Suspension Eyes are used on Upper Yoke while Ball Socket Eyes are used on Lower Yoke for attaching insulators. These connections give greater flexibility than the Form 1 Yokes.

Castings are malleable iron, galvanized.

# TYPE FP-7 OIL CIRCUIT BREAKER

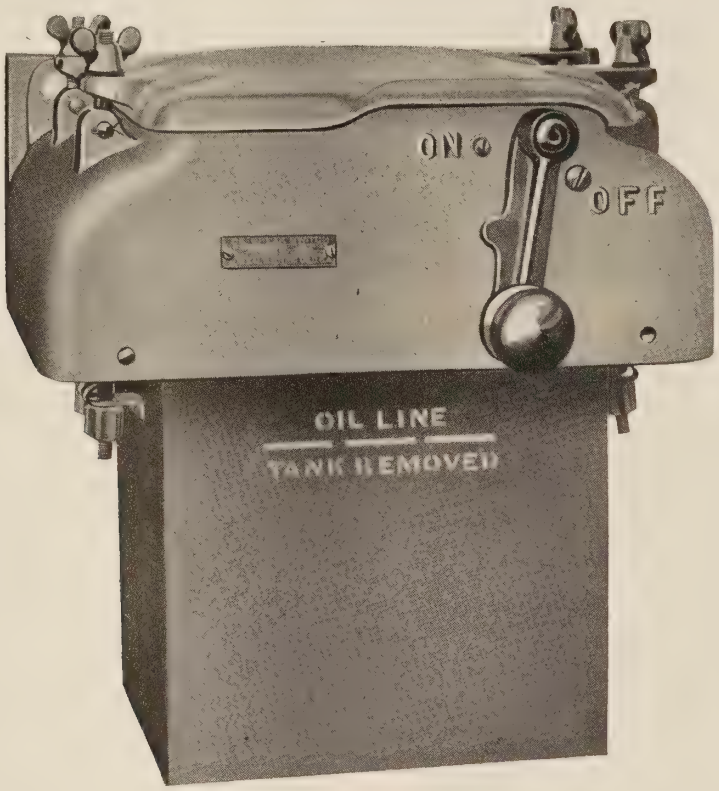
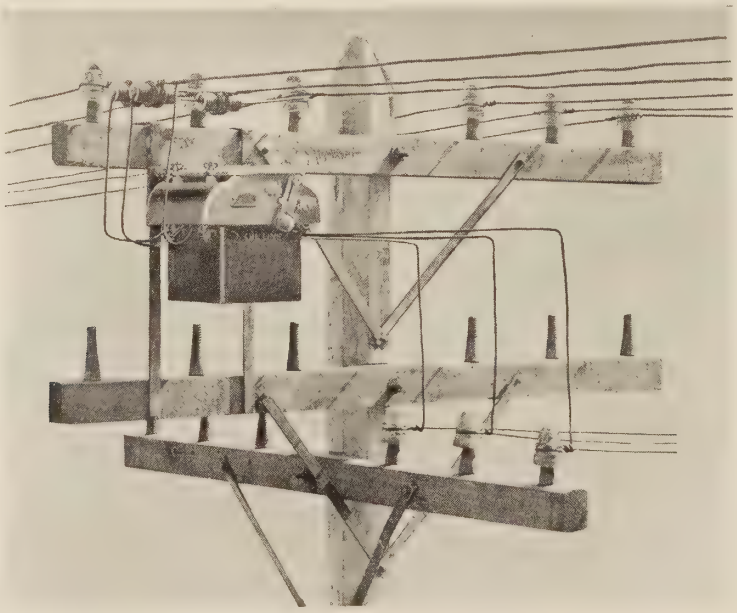



Fig. 1.
Triple-Pole, Single-Throw, 4500-Volt, 100-Ampere Oil Circuit Breaker

THE Type FP-7 oil circuit breaker is for outdoor service and is especially adapted for pole top mounting. It is for use on alternating current, for sectionalizing feeder systems, cutting out transformers, and all classes of service requiring a reliable outdoor breaker to be operated under load within the limits of its rating. In many instances the use of a Type FP-7 oil circuit breaker in connection with a transformer will obviate the necessity of bringing high tension lines into the building.

Breakers listed are all non-automatic. They are manually operated and the open or closed positions of the breaker are indicated by raised letters on the frame. Throwing the handle over to "on" closes, and to "off" opens the breaker. These breakers are rated at 4500 volts, 100 amperes, and either 7500 or 15,000 volts, 200 amperes.



# TYPE FK-20 OIL CIRCUIT BREAKERS

## For Industrial Service up to 300 Amperes and 2500 Volts

TYPE FK-20 oil circuit breakers are intended primarily for use with induction motors in industrial applications. They possess features which render them particularly well suited for such service. Under proper supervision they are successfully used in some of the more dangerous branches of industrial service, such as textile and flour mills, gas works, coal mines, in the pumping and refining of oil, etc., where inflammable dust or gases are present.

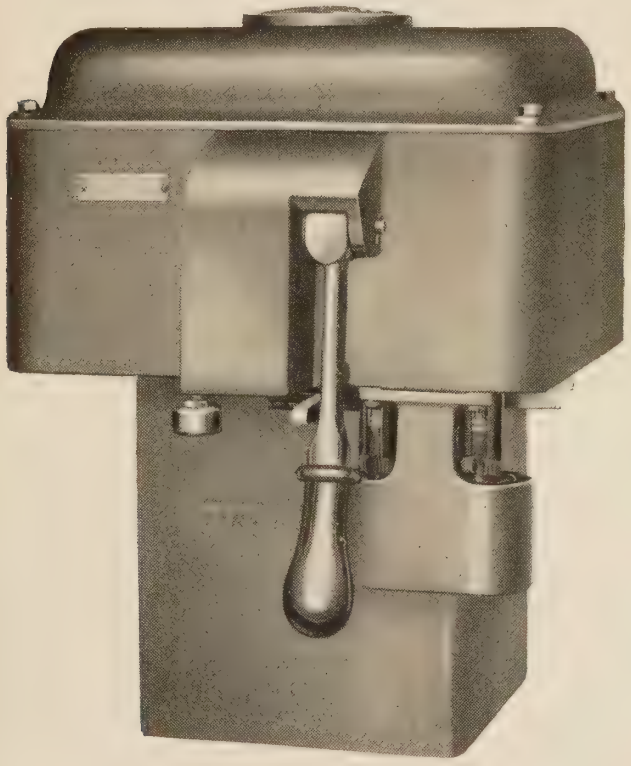


Fig. 1
Type FK-20 Oil Circuit Breaker with Series Trip Coils and Under Voltage Device

Automatic breakers may be effectively used as branch feeder cutouts in the place of enclosed fuses, especially on 2500-volt work in textile mills and similar installations.

While Type FK-20 oil circuit breakers are totally enclosed for the purpose of rendering them dustproof, they are not waterproof and should not be used out of doors unless protected by shelter or housing.

Type FK-20 oil circuit breakers are not recommended for use out of doors, or indoors when directly connected to incoming lines where they will be subjected to surges or other voltage disturbances, unless they are protected by lightning arresters or other surge protective devices. Breakers so used require a greater safety factor of insulation than breakers normally used indoors in industrial applications.

## Features

Safe—All live parts entirely enclosed.

Reliable — Excellent electrical and mechanical design, not requiring operation by skilled labor.

Durable — Strong construction, insuring long life of all parts.

Flexible — Combinations to meet wide range of conditions.

Compact—Few operating parts and these arranged in systematic manner.

Simple — All parts supported by frame, making installation easy.

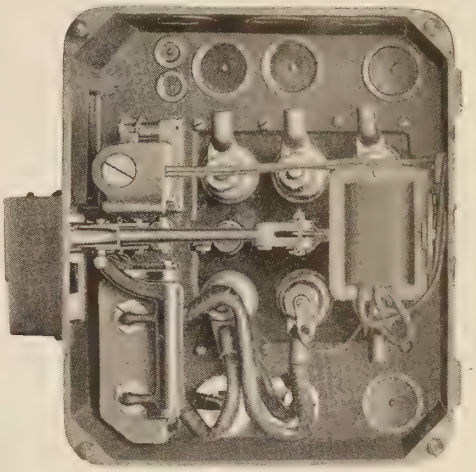


Fig. 2
Type FK-20 Oil Circuit Breaker with Series Trip Coils and Under Voltage Device with Auto Transformer.
(For use on 220–, 440– and 550–volt circuits)

## Mounting

The breaker can be mounted on a wall, post, or other flat surface, or on a machine by the use of brackets or suitable supports.

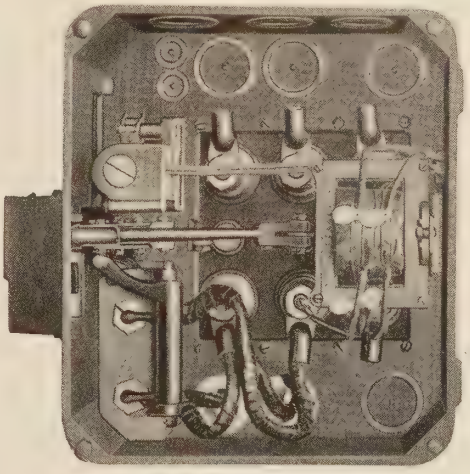


Fig. 3
Type FK-20 Oil Circuit Breaker with Series Trip Coils and Under Voltage Device with Voltage Transformer.
(For use on 2500-volt circuits)

## Capacity

Type FK-20 oil circuit breakers are built in three capacities, non-automatic and automatic, for use on two-,* three-, and four-wire systems up to 2500 volts, as follows:

| Amperes | Poles | Throw |
|---|---|---|
| 60 | Triple and Four | Single |
| 200 | Triple and Four | Single |
| 300 | Triple | Single |

*For use on two-wire circuits a triple-pole breaker is recommended and connections to middle pole omitted.

# INDUCTION VOLTAGE REGULATORS

THE economic generation and distribution of electric power requiring the use of large generating units, the establishment of generating stations of great capacities, the transmission of power at high voltages to step-down transformer substations, and the distribution of this power to the consumers at relatively low voltages, will result in general in unsatisfactory voltage variations, due to the variations in the load of the various feeders, unless means are provided for its adjustment.

The voltage of a generator, or of a number of generators in the same station, may automatically be maintained constant, regardless of the load, at the station bus or at any point on the transmission system, by means of a generator voltage regulator, but this arrangement is not satisfactory for the control of individual feeders. One feeder may serve a business district, while another from the same generator may serve a residence district, and since the amount of compensation required depends on the load, and since the peak of the load occurs at different times in different feeders, the regulation of the individual feeder is essential if good regulation is to be obtained on the entire system.

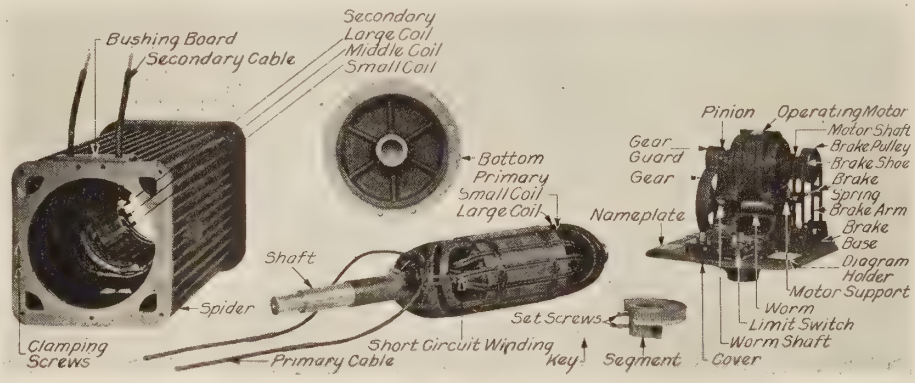



Fig. 1. Disassembled View of a 2300-Volt Single-phase Induction Regulator for Distributing Circuit

In order to meet different requirements and satisfy varying conditions, the General Electric Company has designed and developed the Induction Voltage Regulator.

All induction regulators are variable ratio transformers, or rather compensators, having two separate and distinct windings, primary and secondary, connected respectively across, and in series with the feeder to be controlled. The product of the volts and amperes on the generator or busbar side is always equal to the product of the volts and amperes on the feeder side, less the small loss in the regulator itself.

Induction regulators are built single-phase or polyphase, and are designated by the type letters IRS for the single-phase, IRQ for the quarter-phase, IRT for the three-phase. Although used principally for the control of lighting circuits, they are equally well adapted to power circuits, either single-phase or polyphase.

In all induction regulators manufactured by the General Electric Company, two windings are arranged on separate, circular, concentric sheet iron cores, one of which is stationary, and the other arranged so that it may be partially rotated within the former. The series or secondary winding is arranged in slots on the inside circumference of the stationary core, and the shunt or primary winding in similar slots on the outside circumference of the movable core, and the variation in the feeder voltage produced by the regulator is entirely due to the change in the angular positions of these cores.

This construction is shown in Fig. 1, which is a view of a partially disassembled single-phase induction regulator. The windings on both stationary and movable cores are in effect polar windings. With a given pole of the primary opposite a similar pole of the secondary, the regulator will boost the line voltage, but will lower it if opposite a dissimilar pole; and the change from "boost" to "lower" is gradual as a given primary pole is rotated through the angle between a similar and a dissimilar pole of the secondary.

Induction regulators may be designed for installation in the station as shown in Figs. 2 and 3 or may be modified for outdoor installation as shown in Fig. 5. Station type regulators may be designed for hand operating, remote control motor operation or for automatic operation, the last method being the most used. Regulators for outdoor installation are furnished for automatic operation.

A special regulator has also been developed for the control of small feeders. This regulator is designated as the Type PIRS regulator and is shown in Fig. 4.

This type of regulator is built in the single-phase design only. It is entirely self-contained, i. e., the regulator itself together with all of the control and operating mechanism is assembled in a cast iron tank. This regulator is operated and controlled without any current-making or -breaking contacts or devices. The operating motor is running continuously and the operation of the voltage relay is entirely mechanical. The regulator is simple in design, the various parts are of substantial and rigid construction, ample facilities are provided for lubrication and it will, therefore, require a minimum of attention.

Ask Pettingell-Andrews Company for a catalog showing the complete line of Induction Voltage Regulators.

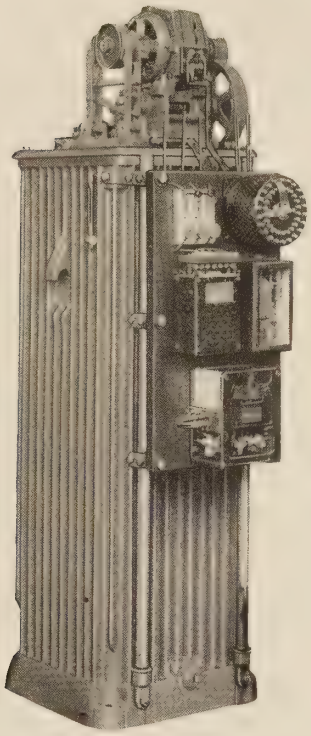


Fig. 2. Single-phase Automatic Induction Regulator with Auxiliaries Mounted on Panel

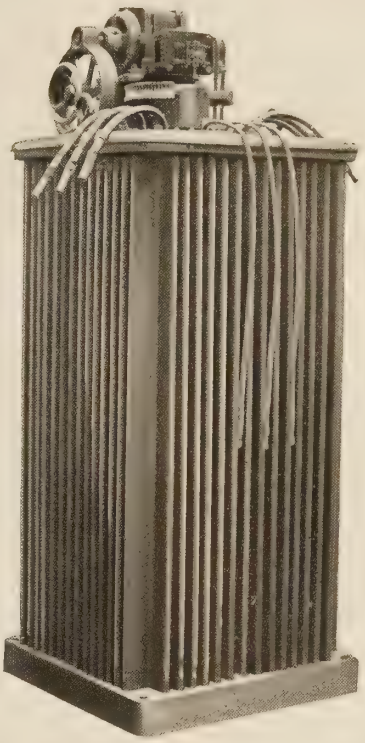


Fig. 3. Three-phase Automatic Self-cooled Induction Regulator

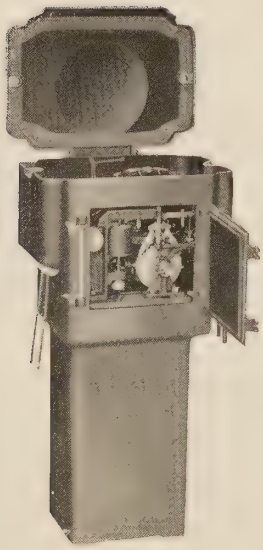


Fig. 4. Single-phase Automatic 2300-volt Pole-type Regulator

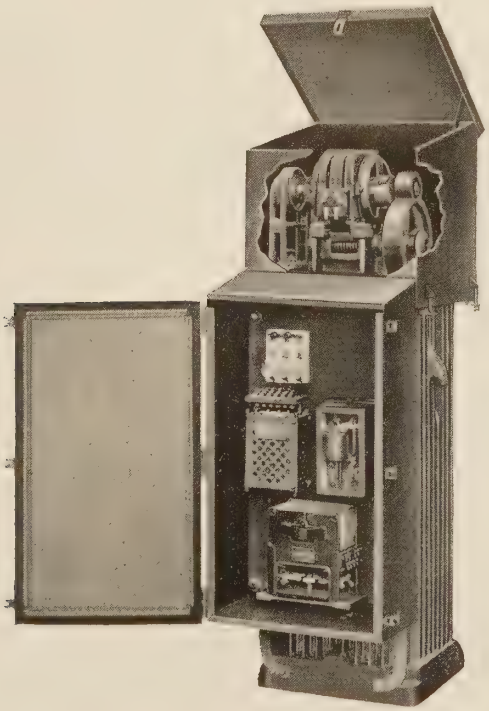


Fig. 5. Single-phase Automatic Regulator Arranged for Outdoor Installation

# DISTRIBUTION TRANSFORMERS

*The Standard of Quality*

SINGLE-PHASE and three-phase transformers of sizes 200 kv-a. and smaller, of any voltage rating, are designated as "Distribution Transformers." This deals with single-phase and three-phase distribution transformers for 25- and 60-cycle circuits, and for operation on standard high voltages of 460 to 34,500 volts inclusive, and low voltages for standard lighting, power and secondary distribution voltages.

As no single form of construction can be ideal for this wide range in sizes and voltage ratings, several forms of construction have been developed and standardized for GE Distribution Transformers. Each of these constructions is particularly adapted to the zone wherein it is standard.

The constructions selected for single-phase transformers utilize the two-,three- or four-part distributed core. (See Fig. 2.)

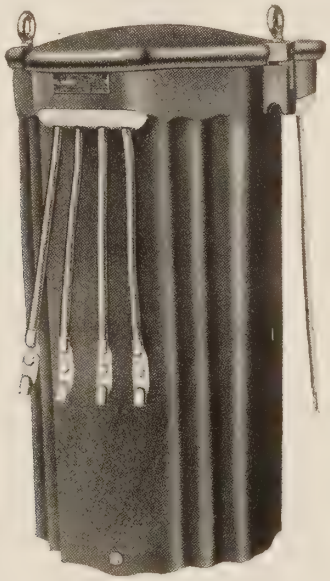


Fig. 1. Type H Distributed Core Distribution Transformer, 25-KV-A., for 2300-115 Volts

Various coil constructions have been developed to meet the particular requirements of designs depending upon unit size and voltage rating. In the larger sizes, circular coils of either disk or cylindrical form are used on account of their greatly superior mechanical qualities, and the facilities they give for rigid mechanical support.

Fig. 2. Various Kinds of Cores

Fig. 2A. Two-Part Distributed Core Partially Assembled

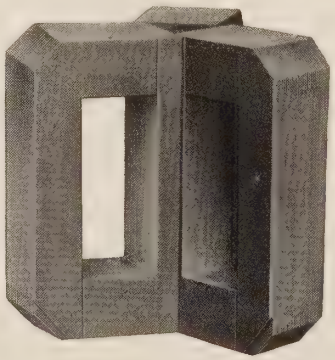


Fig. 2B. Three-Part Distributed Core

GE Three-phase Distribution Transformers utilize three-legged cores with one phase of the winding assembled on each leg. The windings are cylindrical or approximately cylindrical in form.

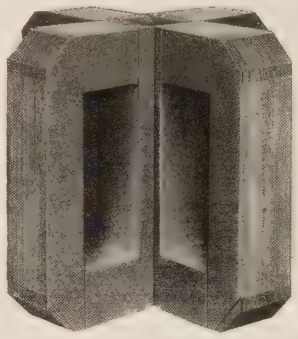


Fig. 2C. Four-Part Distributed Core

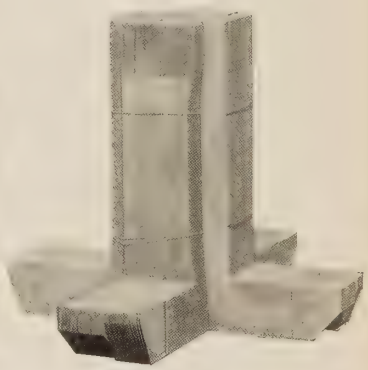


Fig. 2D. Four-Part Distributed Core Partially Assembled

## Single-Phase Transformers

### INSULATION

It may truthfully be said that a transformer is no better than its insulation, for upon this material depends not only the safety and reliability of the apparatus alone, but the life and property of the user of electrical appliances. The selection of insulating material for GE Distribution Transformers has been made after years of scientific research and careful study of the service performance of the thousands of GE Distribution Transformers in operation. Only material best fitted for the particular requirements is used. Each piece of insulation is subject to thorough electrical and mechanical tests and rigid inspection before it enters into the construction of the transformer.

All wire used in Type H transformers is insulated in our own factories by skilled workmen, thereby insuring the dependability of its insulation.

A prominent feature in GE Distribution Transformers in smaller sizes is the special mica insulating pad between low tension and high tension circuits. This composite insulation has the necessary qualities for standing up under all electrical conditions, and is subjected to a high potential test many times greater than the voltage of the transformer. A similar pad is used between ends of the high-voltage coils and the core. In these transformers, therefore, the high-voltage winding is practically surrounded by fireproof insulation.

In transformers using form-wound coils the insulation between the high-voltage and low-voltage windings, and between the high-voltage winding and core, depends upon the voltage and type of winding.

For transformers using disk high-voltage and cylindrical low-voltage coils, the insulation between the high-voltage and low-voltage windings is composed of oil ducts and a cylinder of "573 compound" which, in addition to its high insulating properties, possesses great mechanical strength. The insula-

tion between the high-voltage winding and the core consists of specially treated fiber barriers and oil ducts.

For transformers using disk high-voltage and disk low-voltage coils assembled interleaved, the insulation between the high-voltage and the low-voltage windings is composed of fiber barriers and oil ducts—the number of barriers and dimensions of the ducts varying with the voltage. The insulation between the high-voltage winding and the core is composed of oil ducts and a cylinder of "573 compound." As sections of the low-voltage windings are placed at both ends of the coil stack next to the core, the ends of the high-voltage winding are well insulated from the core.

The insulation between the low-voltage winding and the core in all core-wound transformers is made up from a specially

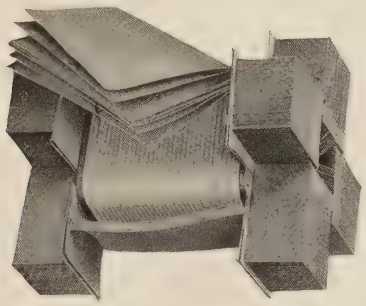


Fig. 4
Partially assembled Type H Transformer showing Mica Pad. Experience has shown the necessity of Fireproof Insulation in Smaller Sizes in order to insure protection of the Low Voltage Circuit in case of burnout from abnormal operating conditions.

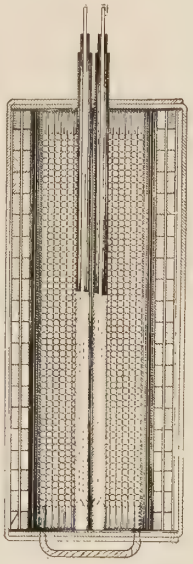


Fig. 5
Diagrammatic sketch of high-voltage leads projected into one plane showing improved way of bringing out the leads and electrically connecting the coils. This exclusive feature of GE Transformers means greatly increased protection against high voltages breaking through to the low-voltage circuit. This arrangement gives maximum distance between high-voltage leads and low-voltage winding and also interposes the impedance of one-half the high-voltage winding to a voltage disturbance entering from the high-voltage line.

treated fiber which possesses suitable insulating properties and is not injured by the mechanical stress incident to the winding process.

## WINDINGS

Transformer windings are of two general types, those wound directly on the core, and those wound on forms, and later assembled on the core. Windings made directly on the core have the advantage of rigid support, the insulations being placed in final fixed positions by the winder and not disturbed or distorted by any assembly process. These advantages are especially desirable in the small units, as here the clearances required by economical design are smallest.

The coils of the three-part distributed core transformers are wound on the core. One-half of the low-voltage coils are usually wound directly over the core insulation. The high-voltage coils and outer low-voltage coils are in turn wound over the inner low-voltage coils, with an insulating pad between all coils (Fig. 5). The windings are provided with suitable oil ducts for uniform cooling—the number and location of the ducts varying with the size of the transformer.

The coils of the four-part distributed-core transformers may be either core-wound or form-wound, depending upon the size and voltage of the transformer. Those wound on the core are wound in the same manner as those of the three-part distributed core transformers described. Form-wound coils are described in succeeding paragraphs.

In the interleaved-disk type of winding (Fig. 3A) both high-

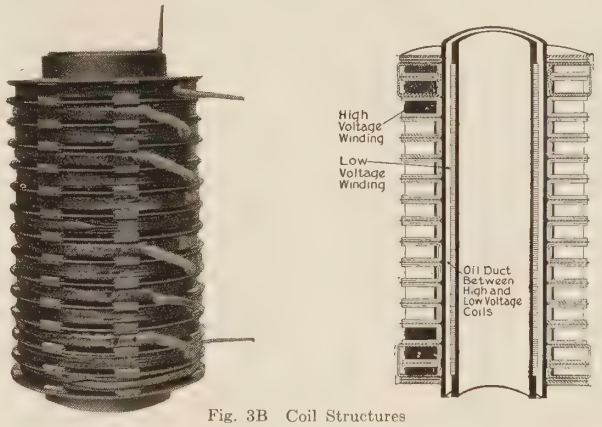



Fig. 3B Coil Structures

and low-voltage coils are wound in the form of disks assembled with the high-voltage and low-voltage coils interleaved. These coils are wound on a form and assembled over a cylinder of "573 compound," this cylinder furnishing the foundation for the winding. This is later assembled over the core and also serves as an insulation between the windings and the core. The coils are separated from each other by means of specially treated fiber spaces, furnishing generous oil ducts between coils for cooling purposes. Between high- and low-voltage windings and where required between coils of either winding, one or more fiber collars are inserted, with oil ducts between.

In the disk-cylinder type of winding (Fig. 3B) the low-voltage coils are cylindrical in shape and are wound on a cylinder of "573 compound." The high-voltage coils are disk coils assembled over another cylinder of the same material, which is in turn assembled over the low-voltage winding with an oil duct between the low-voltage winding and the outer cylinder.

In the cylindrical construction both high- and low-voltage coils are cylinders wound on forms and assembled concentrically, with generous oil ducts between coils.

On the coils of all GE Distribution Transformers where experience has shown the necessity of extra insulating the end turns, this insulation is applied in the form of extra insulation on the conductor, with the addition in some cases of extra layer insulation.

## CORES

The two-part distributed cores are assembled from straight laminations so that the center leg is of cruciform section and the two outer legs of rectangular section. The end laminations are inserted after the windings have been assembled. These cores are strongly clamped by means of structural steel parts which are also utilized in securing the core and coils in the tank.

The three- and four-part cores are built up using "L" shaped laminations assembled in such a manner as to secure a comparatively large center section, with magnetic circuits radiating at

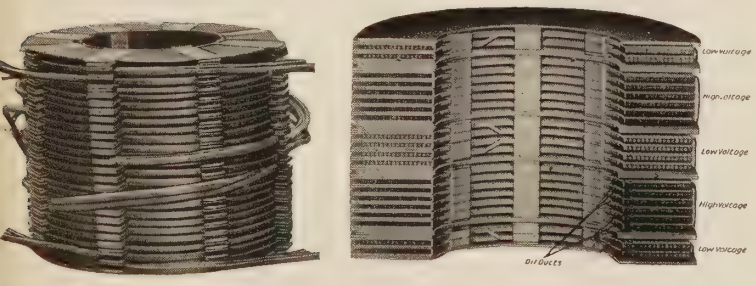
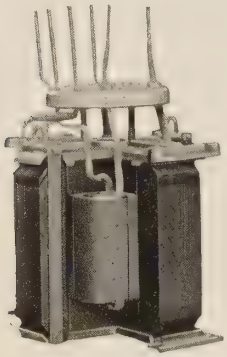
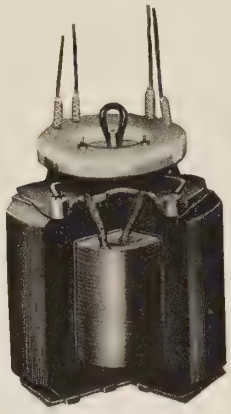



Fig. 3A Coil Structures



Core and Coils of Type H Single-Phase, 60-Cycle, 2300-Volt Transformer Using Four-Part Distributed Core



Core and Coils of Type H Single-Phase, 60-Cycle, 2300-Volt Transformer, Using Three-Part Distributed Core

120 degrees or 90 degrees, respectively. These laminations are interlocked in the center section. The use of "L" shaped punchings materially improves the designs by reducing the number of joints in the magnetic circuit to two, and thus materially lowers the exciting current. The three-part core is so assembled that a nine-sided center leg is produced which gives practically a circular form on which the coils are wound. In the four-part core a center leg having four sides with well-rounded corners is secured so that the winding makes no sharp bends, and is either circular or nearly circular in form depending on the details of design of the core. The outer laminations closing the magnetic circuits are assembled after the winding operation is completed. The three-part core is clamped by means of metal plates at either end of the core, these plates being held together by a bolt passing through the center of the core. In the four-part core, metal straps around the outer legs serve to hold these clamping plates together. These clamping plates in addition serve as a means of clamping the core and coils in the tank.

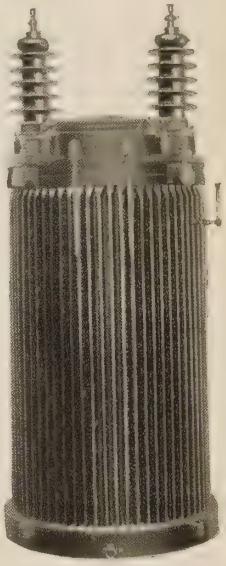
## DRYING AND FILLING

The windings of GE Distribution Transformers are carefully dried under vacuum, and filled under pressure with an insulating compound. This process not only removes all moisture from the insulation and seals the windings against the entrance of moisture, but also makes the winding a solid mass, thus giving it greater mechanical strength and heat conductivity. In the core-wound transformers this treatment is applied to the complete unit, consisting of core and coils. In the form-wound transformers the complete winding is treated as a unit before assembly on the core.

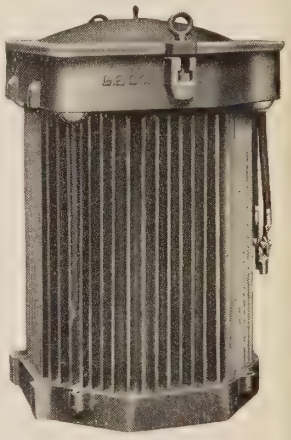
## TANKS

Tanks for GE Distribution Transformers are all of strong weatherproof construction. The smaller units are assembled in smooth cast-iron tanks. As the size of the transformer increases more radiating surface is required. This increase in radiating surface is obtained by means of corrugations in the sides of the tanks. In the larger sizes of distribution transformers, the tanks are made up of corrugated sheet steel sides, cast-welded into the cast-iron base and top rim. These tanks are all provided with cast-iron covers having overhanging lips and with a gasket between the tank and cover preventing the entrance of dust and moisture. Sizes which are suitable for pole-mounting are provided with lugs for attaching hanging hooks. All tanks are provided with lugs for lifting the complete transformer.

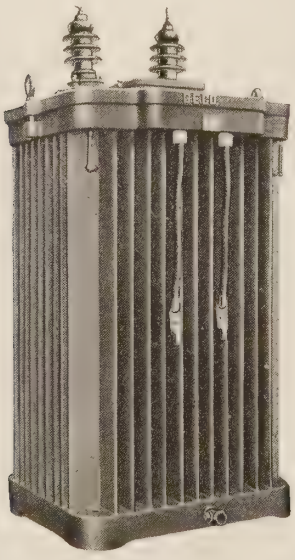
Transformers having voltages below 19,250 volts have the leads brought through bushings located in the overhanging pockets. The leads for transformers of higher voltages than this are brought out through non-puncture bushings located in the cover of the transformer. The joint between the bushing and cover is made weatherproof by means of suitable gaskets.



Large High Voltage Type H Distributed Core Transformer in Corrugated Steel Tank

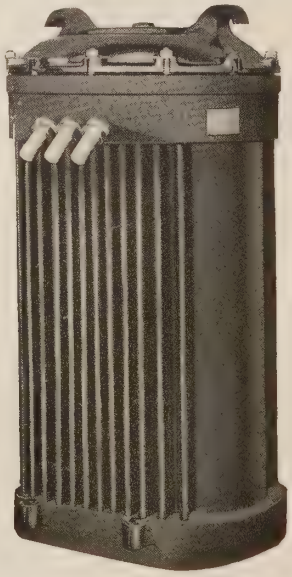


Large Type H Distributed Core Transformer in Corrugated Steel Tank



Large High-Voltage Type H, Form L, Transformer

Type H Subway Transformer in Cast-Iron Tank



Type H Subway Transformer in Corrugated Steel Tank

## Three-Phase Transformers

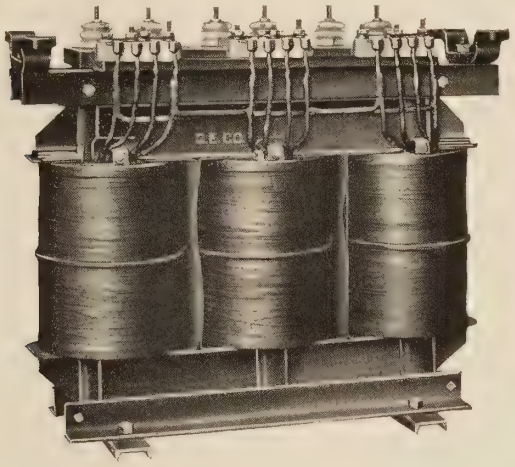
The insulation, drying and filling process, tanks and bushings are in general the same for three-phase transformers as for single-phase transformers.

### WINDINGS

Windings for three-phase distribution transformers follow the same general practice as for single-phase.

### CORES

The cores of the three-phase transformers are made up of laminations assembled to give three vertical legs, one phase winding being assembled on each vertical leg. The cross-



Core and Coils of Type HT Transformer

section of these legs is rectangular for the lower voltages and cruciform for the higher voltages. The core is clamped by structural steel parts which, in addition to serving as core clamps, serve as a means of fastening the core and coils in the tank.

Type HT Transformer in Corrugated Steel Tank

## Oils

The registered trade name TRANSIL when applied to transformer oil sold by the General Electric Company indicates that such oil has characteristics that make it suitable for use in transformers manufactured by the Company and for which it is recommended. It further indicates that the high quality is uniformly maintained as verified by means of periodic tests on samples of oil as shipped.

Because of this fact, and as the quality of oil used in transformers has such a direct influence on the life and successful operation of same, it is obviously impossible for the General Electric Company to recommend any oil other than TRANSIL for use with transformers manufactured by them.

## Auxiliaries

### SUSPENSION HOOKS

All transformers suitable for pole-suspension are provided with suspension hooks which may be attached to the transformer by means of bolts engaging lugs cast in the transformer tank.

### CUTOUTS AND FUSES

GE Distribution Transformers should be protected by suitable cutouts. The type of cutout is determined by the voltage of the circuit and the amount of current to be interrupted. The General Electric Company manufactures two types of cutouts for transformers of distribution sizes and voltages. These are: the plug type and expulsion type.

Expulsion Type Cutout for Voltages above 6600

Expulsion Type Cutout for 6600 Volts

Plug Cutout Cat. No. 104227

### EXPULSION TYPE

The expulsion type cutout is suitable for installation on the cross-arm and is used for voltages and currents higher than those for which the plug type cutout is suitable. One type of expulsion cutout consists of a box of treated ash with hinged door and a tubular fuse holder which is supported on a porcelain fastened to the door, making connection with the line through springs when the door is closed. Upon opening the door the fuse holder is automatically disconnected from the circuit.

A card holder is provided on the bottom of the box just beneath the gas outlet of the fuse holder. When the fuse blows, the expulsion of the gas either punctures the card or forces it out of the holder, thus indicating a blown fuse. This indication may be seen from the ground, making it unnecessary for linemen or inspectors to climb the pole to determine if the fuse is blown.

These cutouts are suitable for use on circuits of 6600 volts and below, 100 amperes and less.

A modification of this cutout is made for circuits of 15,000 to 45,000 volts and currents up to 50 amperes. Although no covering is provided with this cutout it is suitable for outdoor installation.

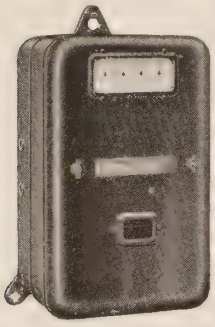
Details and prices furnished by Pettingell-Andrews Company.

# WATTHOUR METERS

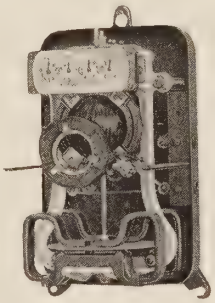
## Thomson Direct Current Watthour Meters

Types C-6 and C-7 Front-Connected
Dull Black Finish

THESE meters are made for direct current circuits. They have extremely high torque, light weight moving element, small commutator gravity control brushes and adjustable shunt field coil. They can be furnished with pressed glass covers and for back connection, prices on application.



TYPE C-6, 100 to 105, 106 to 110, 111 to 115, 116 to 120 VOLTS, TWO-WIRE



TYPE C-6, 200 to 210, 211 to 220, 221 to 230, 231 to 240 VOLTS, TWO-WIRE

| Cat. No. | Amps. | Cat. No. | Amps. | H. P. Rating |
|---|---|---|---|---|
| 37594 | 5 | 37614 | 5 | 1¼ |
| 37595 | 10 | 37615 | 10 | 2 |
| 37596 | 15 | 37616 | 15 | 3½ |
| 37597 | 25 | 37617 | 25 | 7 |
| 37598 | 50 | 37618 | 50 | 15 |
| 37599 | 75 | 37619 | 75 | 20 |
| 37600 | 100 | 37620 | 100 | 25 |
| 37601 | 150 | 37621 | 150 | 40 |
| 37602 | 300 | 37622 | 300 | 80 |
| 37603 | 600 | 37623 | 600 | 160 |

TYPE C-6, 200 to 210, 211 to 220, 221 to 230, 231 to 240 VOLTS THREE-WIRE

TYPE C-7, 500 to 550, 551 to 600 VOLTS, TWO-WIRE

| Cat. No. | Amps. | Cat. No. | Amps. | H. P. Rating |
|---|---|---|---|---|
| | | 37624 | 5 | 2½ |
| 37604 | 5 | 37625 | 10 | 5 |
| 37605 | 10 | 37626 | 15 | 7½ |
| 37606 | 15 | 37627 | 25 | 15 |
| 37607 | 25 | 37628 | 50 | 30 |
| 37608 | 50 | 37629 | 75 | 50 |
| 37609 | 75 | 37630 | 100 | 60 |
| 37610 | 100 | 37631 | 150 | 100 |
| 37611 | 150 | 37632 | 300 | 200 |
| 37612 | 300 | 37633 | 600 | 400 |

Note—Always state normal operating voltage of circuit when ordering.

Approximate shipping weight, all voltages 5 to 50 amp. inclusive, 1 in a box, 26 lb., 2 in a box, 55 lb.; 75 amp. 1 in a box, 35 lb.; 2 in a box, 69 lb.; 100 to 600 amp., 1 in a box, 48 lb.

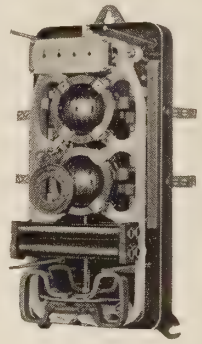
For further information ask Pettingell-Andrews Company for bulletin on this subject.

## Direct Current Astatic Watthour Meters

Type CS-3 Front-Connected Metal Cover
Dull Black Finish

The Type CS-3 is an astatic watthour meter for direct current service and is especially designed by an astatic arrangement of the armature and field coils for operation with accuracy in the presence of stray fields. They can be furnished back connected; prices on application.

100 to 105, 106 to 110, 111 to 115, 116 to 120 VOLTS TWO-WIRE



200 to 210, 211 to 220, 221 to 230, 231 to 240 VOLTS TWO-WIRE

| Cat. No. | Amps. | Cat. No. | H. P. Rating | Amps. |
|---|---|---|---|---|
| 195737 | 15 | 195748 | 4 | 15 |
| 195738 | 25 | 195749 | 7 | 25 |
| 195739 | 50 | 195750 | 15 | 50 |
| 195740 | 75 | 195751 | 20 | 75 |
| 195741 | 100 | 195752 | 25 | 100 |
| 195742 | 150 | 195753 | 40 | 150 |
| 195743 | 200 | 195754 | 50 | 200 |
| 195744 | 300 | 195755 | 80 | 300 |
| 195745 | 400 | 195756 | 100 | 400 |
| 195746 | 600 | 195757 | 160 | 600 |

200 to 210, 211 to 220, 221 to 230, 231 to 240 VOLTS THREE-WIRE

500 to 550, 551 to 600 VOLTS TWO-WIRE

| Cat. No. | Amps. | Cat. No. | H. P. Rating | Amps. |
|---|---|---|---|---|
| 195759 | 15 | 196300 | 10 | 15 |
| 195760 | 25 | 196301 | 15 | 25 |
| 195761 | 50 | 196302 | 30 | 50 |
| 195762 | 75 | 196303 | 50 | 75 |
| 195763 | 100 | 196304 | 60 | 100 |
| 195764 | 150 | 196305 | 100 | 150 |
| 195765 | 200 | 196306 | 125 | 200 |
| 195766 | 300 | 196307 | 200 | 300 |
| 195767 | 400 | 196308 | 250 | 400 |
| | | 196309 | 400 | 600 |

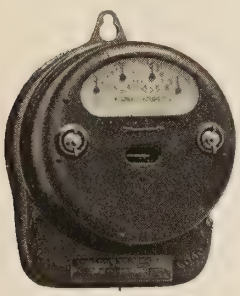
Note—Always state normal operating voltage of circuit when ordering.

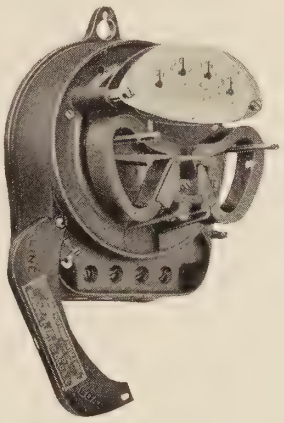
Approximate shipping weight all capacities and voltages, 60 lb.

# Single-Phase Watthour Meters

Type I-14 (For House Service)
Front-Connected, Metal or Glass Cover
Dull Black Finish

This meter is a distinct advance in the art of designing and manufacturing watthour meters operating on the induction principle. It is of pleasing appearance and simple construction and fills the need for a meter of low initial cost and small expense of maintenance and testing.





110 VOLTS

| Amps. | 25–30 Cycles Cat. No. | 40–133 Cycles Cat. No. |
|---|---|---|
| 5 | 152860 | 151942 |
| 10 | 152861 | 151943 |
| 15 | 152862 | 151944 |
| 25 | 152863 | 151945 |
| 50 | 152864 | 151946 |
| 75 | 152865 | 151947 |
| 100 | 152866 | 151948 |
| 150 | 152867 | 151949 |
| 200 | 152868 | 151950 |
| 300 | 152869 | 151951 |

220 VOLTS, 2-WIRE

| Amps. | 25–30 Cycles Cat. No. | 40–133 Cycles Cat. No. |
|---|---|---|
| 5 | 152870 | 151952 |
| 10 | 152871 | 151953 |
| 15 | 152872 | 151954 |
| 25 | 152873 | 151955 |
| 50 | 152874 | 151956 |
| 75 | 152875 | 151957 |
| 100 | 152876 | 151958 |
| 150 | 152877 | 151959 |
| 200 | 152878 | 151960 |
| 300 | 152879 | 151961 |

220 VOLTS, 3-WIRE

| Amps. | 25–30 Cycles Cat. No. | 40–133 Cycles Cat. No. |
|---|---|---|
| 5 | 152880 | 151962 |
| 10 | 152881 | 151963 |
| 15 | 152882 | 151964 |
| 25 | 152883 | 151965 |
| 50 | 152884 | 151966 |
| 75 | 152885 | 151967 |
| 100 | 152886 | 151968 |
| 150 | 152887 | 151969 |

Meters listed above are self-contained, that is, require no instrument transformers. When the currents to be metered exceed 300 amperes, 2-wire, and 150 amperes, 3-wire, current transformers are necessary, or when the voltage of the circuit is more than 600 volts, both current and potential transformers are required. In such cases meters for use on the secondary of transformers should be ordered, designating the meters by catalogue numbers and ratings as given below.

# Meters for Use with Instrument Transformers

2-WIRE

| Cat. No. | Amperes | Volts | Cycles |
|---|---|---|---|
| 188640 | 5 | 110 | 25–30 |
| 188641 | 5 | 110 | 40–133 |
| 188642 | 5 | 220 | 25–30 |
| 188643 | 5 | 220 | 40–133 |

3-WIRE (FOR USE WITH DOUBLE PRIMARY AND SINGLE SECONDARY CURRENT TRANSFORMERS, 800 AMPERES AND BELOW)

| Cat. No. | Amperes | Volts | Cycles |
|---|---|---|---|
| 188642 | 5 | 220 | 25–30 |
| 188643 | 5 | 220 | 40–133 |

3-WIRE (FOR USE WITH TWO CURRENT TRANSFORMERS, WHERE CAPACITY EXCEEDS 800 AMPERES)

| Cat. No. | Amperes | Volts | Cycles |
|---|---|---|---|
| 188644 | 5 | 220 | 25–30 |
| 188645 | 5 | 220 | 40–133 |

For 3-wire transformer rated circuits 800 amperes and below, the 2-wire meter, Cat. No. 188642 or 188643 is used with a double primary and single secondary 5-ampere winding current transformer. For circuits above 800 amperes, the 3-wire meter, Cat. No. 188644 or 188645 is used with two single primary transformers.

These catalogue numbers cover the meter only and do not include transformers which should be ordered in addition giving complete rating. Unless otherwise specified meters when ordered with transformers will be calibrated and furnished with suitable register to read directly the primary energy. These meters may be used on circuits the voltage of which is not more than 10 per cent. above or below the rated voltage of the meter. When ordering meters for voltages outside of these limits the normal operating voltage must be specified.

Approximate shipping weight, all voltages, metal covers, 5 to 25 amperes inclusive, 1 in a box, 15 lb.; 2 in a box, 27 lb.; 4 in a box, 44 lb.; 8 in a box, 84 lb.; 50 and 75 amperes, 1 in a box, 17 lb.; 2 in a box, 30 lb.; 4 in a box, 55 lb.; 100 and 150 amperes, 1 in a box, 32 lb.; 2 in a box, 65 lb.; 4 in a box, 95 lb.; 200 and 300 amperes 2-wire, 1 in a box, 35 lb.; 2 in a box, 67 lb.

These meters may be used on circuits the voltage of which is not more than 10 per cent. above or below the rated voltage of the meter. When ordering meters for voltages outside of these limits specify the normal operating voltage.

Note. — Orders cannot be filled unless voltage given above or the operating voltage is given; also specify frequency of circuit.

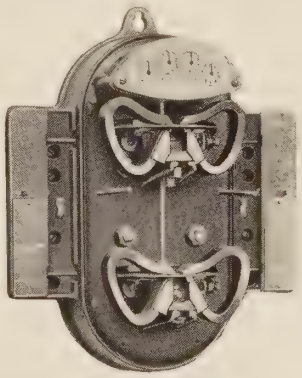
# Polyphase Watthour Meters

Type D-6 (For House Service)

Front-Connected, Metal or Glass Cover, Dull Black Finish

25-133 Cycles

This meter is designed for the specific purpose of measuring the energy of a polyphase circuit, the metering of which involves the use of two or more single-phase meters or their equivalent. This so-called polyphase meter is a combination of single-phase meters in one case, acting on one moving element and recording on a single dial. The electrical element is similar to that of the I-14 meter having identical electrical characteristics but adapted for measuring the energy delivered through any of the following circuits: 3-wire, 3-phase; 3-wire, 2-phase; 4-wire, 2-phase; 4-wire, 3-phase.



110 VOLTS

| Cat. No. | | Amperes | Kw. Capacity Non-Ind. Loads | Motor H. P. Rating 2- and 3-Phase |
|---|---|---|---|---|
| 3-Wire 3-Phase, 3-Wire 2-Phase | 4-Wire 2-Phase | | | |
| 172255 | 172307 | 5 | 1 | 1 |
| 172256 | 172308 | 10 | 2 | 2 |
| 172257 | 172309 | 15 | 3 | 3 |
| 172258 | 172310 | 25 | 5 | 5 |
| 172259 | 172311 | 50 | 10 | 10 |
| 172260 | 172312 | 75 | 15 | 15 |
| 172261 | 172313 | 100 | 20 | 20 |
| 172262 | 172314 | 150 | 30 | 30 |

220 VOLTS

| Cat. No. | | Amperes | Kw. Capacity Non-Ind. Loads | Motor H. P. Rating 2- and 3-Phase |
|---|---|---|---|---|
| 3-Wire 3-Phase, 3-Wire 2-Phase | 4-Wire 2-Phase | | | |
| 172268 | 172315 | 5 | 2 | 2 |
| 172269 | 172316 | 10 | 4 | 4 |
| 172270 | 172317 | 15 | 6 | 6 |
| 172271 | 172318 | 25 | 10 | 10 |
| 172272 | 172319 | 50 | 20 | 20 |
| 172273 | 172320 | 75 | 30 | 30 |
| 172274 | 172321 | 100 | 40 | 40 |
| 172275 | 172322 | 150 | 60 | 60 |

440 VOLTS

| Cat. No. | | Amperes | Kw. Capacity Non-Ind. Loads | Motor H.P. Rating 2- and 3-Phase |
|---|---|---|---|---|
| 3-Wire 3-Phase, 3-Wire 2-Phase | 4-Wire 2-Phase | | | |
| 172281 | 172323 | 5 | 4 | 4 |
| 172282 | 172324 | 10 | 8 | 8 |
| 172283 | 172325 | 15 | 12 | 12 |
| 172284 | 172326 | 25 | 20 | 20 |
| 172285 | 172327 | 50 | 40 | 40 |
| 172286 | 172328 | 75 | 60 | 60 |
| 172287 | 172329 | 100 | 80 | 80 |
| 172288 | 172330 | 150 | 120 | 120 |

550 VOLTS

| Cat. No. | | Amperes | Kw. Capacity Non-Ind. Loads | Motor H.P. Rating 2- and 3-Phase |
|---|---|---|---|---|
| 3-Wire 3-Phase, 3-Wire 2-Phase | 4-Wire 2-Phase | | | |
| 172294 | 172331 | 5 | 5 | 5 |
| 172295 | 172332 | 10 | 10 | 10 |
| 172296 | 172333 | 15 | 15 | 15 |
| 172297 | 172334 | 25 | 25 | 25 |
| 172298 | 172335 | 50 | 50 | 50 |
| 172299 | 172336 | 75 | 75 | 75 |
| 172300 | 172337 | 100 | 100 | 100 |
| 172301 | 172338 | 150 | 150 | 150 |

220 △ 127 Y VOLTS, FOUR-WIRE, THREE-PHASE

| Cat. No. | Amperes | Kw. Capacity Non-Ind. Loads | Motor H.P. Rating 2- and 3-Phase |
|---|---|---|---|
| 4-Wire 3-Phase | | | |
| 172625 | 5 | 2 | 2 |
| 172626 | 10 | 4 | 4 |
| 172627 | 15 | 6 | 6 |
| 172628 | 25 | 10 | 10 |
| 172629 | 50 | 20 | 20 |
| 172630 | 75 | 30 | 30 |

440 △ 254 Y VOLTS, FOUR-WIRE, THREE-PHASE

| Cat. No. | Amperes | Kw. Capacity Non-Ind. Loads | Motor H.P. Rating 2- and 3-Phase |
|---|---|---|---|
| 4-Wire 3-Phase | | | |
| 172631 | 5 | 4 | 4 |
| 172632 | 10 | 8 | 8 |
| 172633 | 15 | 12 | 12 |
| 172634 | 25 | 20 | 20 |
| 172635 | 50 | 40 | 40 |
| 172636 | 75 | 60 | 60 |

Meters listed above are self-contained, that is, require no instrument transformers When the currents to be metered exceed 150 amperes, 3-wire, 3-phase; 3-wire, 2-phase; 4-wire, 2-phase; and 75 amperes, 4-wire, 3-phase; current transformers are necessary; or when the voltage is more than 600 volts, 3-wire, 3-phase; 3-wire, 2-phase; 4-wire, 2-phase; or more than 600 △ volts, 4-wire, 3-phase, both current and potential transformers are required. In such cases, meters for use on the secondary of transformers should be ordered, designating the meters by catalogue numbers and ratings as given on the following page.

Watthour Meters of Switchboard Types. Information and prices furnished by Pettingell-Andrews Company on application.

## Polyphase Watthour Meters (Concluded)

Type D-6 (For House Service)

For Use with Instrument Transformers

Front-Connected, Metal or Glass Cover, Dull Black Finish

25-133 Cycles

FOR THREE-PHASE THREE-WIRE, TWO-PHASE THREE- AND FOUR-WIRE CIRCUITS

| Cat. No. | Amperes | Volts | Cat. No. | Amperes | Volts |
|---|---|---|---|---|---|
| 188633 | 5 | 110 | 188635 | 5 | 440 |
| 188634 | 5 | 220 | 188636 | 5 | 550 |

## For Three-Phase Four-Wire Circuits Only

| FOR USE WITH THREE CURRENT AND TWO POTENTIAL TRANSFORMERS | | | FOR USE WITH THREE CURRENT TRANSFORMERS ONLY | | |
|---|---|---|---|---|---|
| Cat. No. | Amperes | Volts | Cat. No. | Amperes | Volts |
| 188637 | 5 | 190 △<br>110 Y | 188638 | 5 | 220 △ 127 Y |
| | | | 188639 | 5 | 440 △ 254 Y |

The catalogue numbers cover the meter only and do not include transformers which should be ordered in addition giving complete rating. Unless otherwise specified, meters when ordered with transformers will be calibrated and furnished with suitable register to read directly the primary energy. These meters may be used on circuits the voltage of which is not more than 10 per cent above or below the rated voltage of the meter. When ordering meters for voltages outside of these limits the normal operating voltage must be specified.

Approximate shipping weight all voltages, 5 to 25 amperes, 1 in a box, 34 lb.; 2 in a box, 60 lb.; 50 and 75 amperes, 1 in a box, 45 lb.; 2 in a box, 85 lb.; 100 and 150 amperes, 1 in a box, 49 lb.; 2 in a box, 90 lb.

Always state nature and frequency of circuit and if for 4-wire, 3-phase, give both "Delta" and "Y" voltages.


To Central Stations

The Automobile Division of the Pettingell-Andrews Company has special inducements to offer you on

EVEREADY

STORAGE BATTERIES

YALE BULLDOG

CORD AND FABRIC TIRES

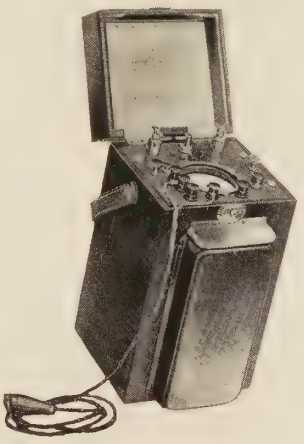
GE TUNGAR RECTIFIERS

(For Battery Charging)

Ask about the Special Offer


# TEST METERS

THE question of periodical meter testing is of vital importance to every central station or isolated plant, since the revenue received depends upon the accuracy of the meters used. The use of the portable testing meter is recognized as the best and most efficient way of testing service meters. The time and labor saving features which result in increased efficiency are obvious. Moreover, the use of the portable test meter results in greater accuracy, as errors due to fluctuating voltage, load, personal errors, etc., are eliminated. The test meter combines in one standard several capacities covering a range from light load to full load, making possible rapid testing, since no time is lost in changing standards. In using the test meter constant load is unnecessary, since the only observations required are the number of disk revolutions of the meter undergoing test, and the pointer indications of the meter before and after test. Personal errors of observation are practically eliminated.



Type CB-5 Test Meter

Type IB-5 Test Meter

## Type CB-5 (For Direct Current)

| Cat. No. | Amperes | Volts | Ship. Wt. in Lb. |
|---|---|---|---|
| 156643 | 1/2/10/20/40 | 100–120 | 48 |
| 156644 | 1/2/10/20/40 | 100–120 / 200–240 | 48 |
| 60646 | 5/10/50/100 | 100–120 | 50 |
| 60647 | 5/10/50/100 | 100–120 / 200–240 | 50 |

## Type IB-5 (For Alternating Current)

| Cat. No. | Amperes | Volts | Cycles | Ship. Wt. in Lb. |
|---|---|---|---|---|
| 152996 | 1 and 10 | 100 120 | 25–125 | 20 |
| 152997 | 1 and 10 | 100–120 / 200–240 | 25–125 | 20 |

## Type IB-6 (For Alternating Current)

| Cat. No. | Amperes | Volts | Cycles | Ship. Wt. in Lb. |
|---|---|---|---|---|
| 174925 | 1/5/10/50/100 | 100–120 | 25–125 | 24 |
| 174926 | 1/5/10/50/100 | 100–120 / 200–240 | 25–125 | 24 |

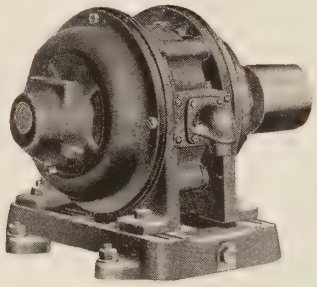
Note.—Orders must give the operating voltage, and if for alternating current, the frequency of the circuit.

# STATIONARY MOTORS

## For Alternating and Direct Current Circuits

### Selection of Motors

IN the following pages, space available permits only the listing of those stationary belted AC and DC motors in most common demand for general purpose uses. The standard types shown will meet the larger part of power requirements for industrial and miscellaneous motor drives. By means of slight mechanical or



Type KT Riveted Frame
Constant Speed Induction Motor

electrical modifications, standard GE motors can be adapted to a large variety of machines. When either standard or special drives are involved our customers may count on satisfactory stock and service facilities backed by the designing, engineering and manufacturing resources of the General Electric Company.

Since to secure the best results for motor drives the proper selection of starting and control accessories is indispensable, customers are urged to take advantage of our contact with the highly specialized GE Industrial Control Department in connection with the simpler as well as the more complex applications requiring the correct combination of motor and accessory devices.

In placing motor orders, the following information should be given:

Type of Motor required.

HP—speed and voltage (if motor is to be used on alternating circuit, also state frequency and whether for single-, two- or three-phase circuits).

If service is direct current, state winding, i. e., shunt, series or compound.

If motors are to be operated in situations exposed to excessive dampness, heat, acid fumes, etc., state conditions so that special provision may be made for proper motor enclosure.

State accessories; (e.g. standard starting rheostat,) if provision should be made for long-distance or automatic control, push button start and stop, etc.

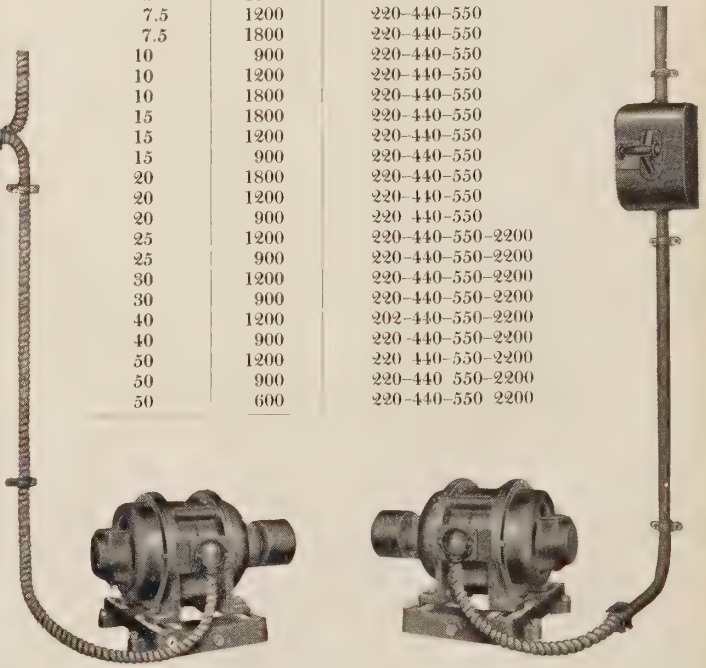
### Two- and Three-Phase Constant Speed Induction Motors

Further data and prices on application covering other 60 cycle ratings and speeds as well as information on complete lines of 25, 40 and 50 cycle motors.

Type KT Form B Skeleton Frame
Constant Speed Induction Motor

60 CYCLES—TYPES "KT" AND "KQ"

| H. P. | SPEED R. P. M. | VOLTS |
|---|---|---|
| ½ | 1200 | 110–220–440–550 |
| ¾ | 1200 | 110–220–440–550 |
| ¾ | 1800 | 110–220–440–550 |
| 1 | 1200 | 110–220–440–550 |
| 1 | 1800 | 110–220–440–550 |
| 1½ | 1200 | 110–220–440–550 |
| 1½ | 1800 | 110–220–440–550 |
| 2 | 1200 | 110–220–440–550 |
| 2 | 1800 | 110–220–440–550 |
| 3 | 1200 | 110–220–440–550 |
| 3 | 1800 | 110–220–440–550 |
| 5 | 1200 | 110–220–440–550 |
| 5 | 1800 | 110–220–440–550 |
| 7.5 | 1200 | 220–440–550 |
| 7.5 | 1800 | 220–440–550 |
| 10 | 900 | 220–440–550 |
| 10 | 1200 | 220–440–550 |
| 10 | 1800 | 220–440–550 |
| 15 | 1800 | 220–440–550 |
| 15 | 1200 | 220–440–550 |
| 15 | 900 | 220–440–550 |
| 20 | 1800 | 220–440–550 |
| 20 | 1200 | 220–440–550 |
| 20 | 900 | 220–440–550 |
| 25 | 1200 | 220–440–550–2200 |
| 25 | 900 | 220–440–550–2200 |
| 30 | 1200 | 220–440–550–2200 |
| 30 | 900 | 220–440–550–2200 |
| 40 | 1200 | 202–440–550–2200 |
| 40 | 900 | 220–440–550–2200 |
| 50 | 1200 | 220–440–550–2200 |
| 50 | 900 | 220–440–550–2200 |
| 50 | 600 | 220–440–550–2200 |



FP-10—Oil Circuit Breaker with Conduit Connection to Induction Motor

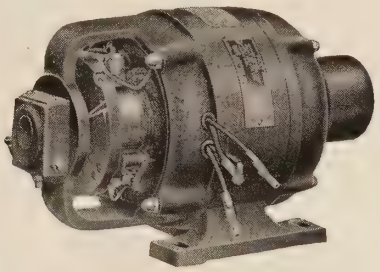
CR-1038—Switch with Conduit Connection to Induction Motor

# Repulsion Induction Single-Phase Motors Type "RI"

The Type "RI" Repulsion Induction Motor is designed for either constant or varying speed. "RI" motors will start and accelerate loads having 2½ times full load torque.

In starting direct from the line, Type "RI" motors take current approximately in proportion to torque. If desired to reduce current values during acceleration, Type CR-1025 rheostats should be ordered.

Standard motors may be operated on either 110 or 220 volt circuits, by simply interchanging the lead connections. CR-1025 starters reduce the current at starting and are especially recommended for sizes 7½ HP and larger.



Type RI ½ H. P. Open Motor

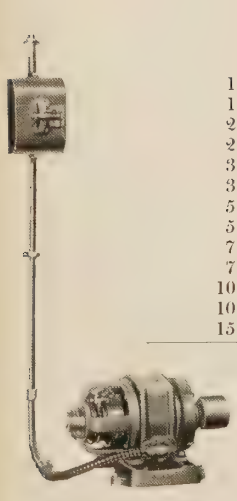
Standard double-pole, single-throw CR-1038 safety enclosed switch with two protective plugs provides overload but not under-voltage protection.

Standard double-pole, single-throw CR-1035, FP-10 oil circuit breaker with overload trips provides overload and under-voltage protection.

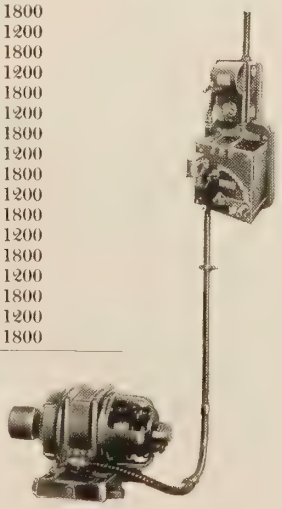
Type LM switch and CR-1025 resistance starter provides both overload and under-voltage protection.

TYPE RI MOTORS—60 CYCLES
110 OR 220 VOLTS CONSTANT SPEED

| HP | Speed RPM |
|---|---|
| ¼ | 1800 |
| ¼ | 1200 |
| ½ | 1800 |
| ½ | 1200 |
| ¾ | 1800 |
| ¾ | 1200 |
| 1 | 1800 |
| 1 | 1200 |
| 2 | 1800 |
| 2 | 1200 |
| 3 | 1800 |
| 3 | 1200 |
| 5 | 1800 |
| 5 | 1200 |
| 7½ | 1800 |
| 7½ | 1200 |
| 10 | 1800 |
| 10 | 1200 |
| 15 | 1800 |



CR-1038 Switch Conduit Connected to RI Motor

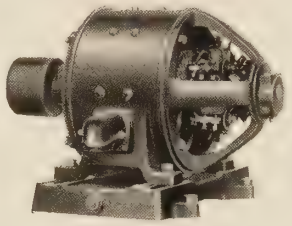


Type LM Switch and CR-1025 Resistance Starter with RI Motor.

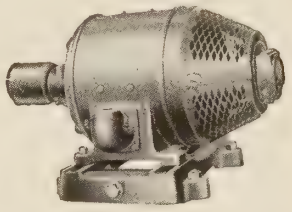
# Commutating Pole Direct Current Motors Type "RC"

Ratings and brief data on the new line of General Electric Commutating Pole, Direct Current Motors are given herewith. These motors are superior to machines of non-commutating pole design in operating characteristics, freedom from sparking, and, in general, as possessing a higher degree of all-day service efficiency.

Iron sliding bases and starting rheostats are included with standard belted motors. Semi-enclosing or solid enclosing covers may be furnished on special order. The use of enclosing covers increases the temperature rise of motors to which they are applied and therefore modifies the open ratings. Belt tightener attachments, consisting of cast iron ring adjustable idler on pulley end, may be furnished on order.



Type RC Open Motor

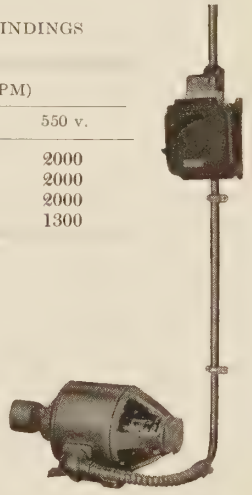


Type RC Semi-Enclosed Motor

TYPE "RC" MOTORS OPEN AND SELF-VENTILATED RATINGS
STANDARD SHUNT OR COMPOUND WINDINGS

| Frame No. | Horse-power | Speed (RPM) 115 & 230 v. | Speed (RPM) 550 v. |
|---|---|---|---|
| 21A | ½ | 1800 | 2000 |
| 21B | ¾ | 1700 | 2000 |
| 22 | 1 | 1700 | 2000 |
| 23B | 1 | 1150 | 1300 |

Type LM–4 Enclosed Lever Switch



Type RC Motor with CR-1000 Rheostat and Enclosing Cover

TYPE "RC" RATINGS (Continued)

| Frame No. | Horse-power | Speed (RPM) 115 & 230 v. | Speed (RPM) 550 v. |
|---|---|---|---|
| 23B | 1½ | 1700 | 2000 |
| 24 | 2 | 1700 | 2000 |
| 25 | 2 | 1150 | 1300 |
| 25 | 3 | 1700 | 1900 |
| 26A | 3 | 1100 | 1300 |
| 26A | 5 | 1700 | 1900 |
| 27A | 5 | 1150 | 1300 |
| 27A | 7½ | 1700 | 1800 |
| 27B | 7½ | 1150 | 1300 |
| 27B | 10 | 1700 | 1800 |
| 29A | 7½ | 850 | 900 |
| 29A | 10 | 1150 | 1250 |
| 29A | 15 | 1700 | 1800 |

TYPE RC RATINGS (Continued from page 77)

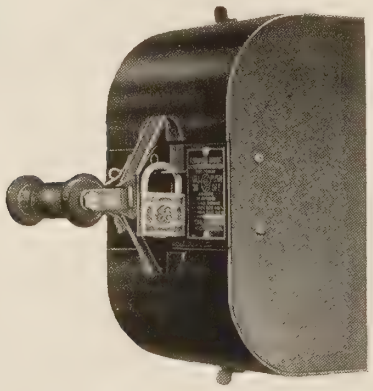
| Frame No. | Horse Power | Speed (RPM) | |
|---|---|---|---|
| | | 115 & 230 v. | 550 v. |
| 29 | 10 | 850 | 900 |
| 29 | 15 | 1150 | 1250 |
| 30 | 15 | 850 | 900 |
| 30 | 20 | 1150 | 1250 |
| 31B | 20 | 800 | 875 |
| 31 | 25 | 1150 | 1250 |
| 32 | 25 | 800 | 925 |
| 31B | 30 | 1150 | 1250 |
| 33 | 30 | 775 | 900 |
| 32 | 40 | 1100 | 1250 |
| 34 | 40 | 750 | 875 |
| 33 | 50 | 1075 | 1225 |
| 35 | 50 | 700 | 825 |

The temperature rise of Open, Semi-enclosed and Enclosed Self-ventilated Type "RC" motors, operating at full load and rated voltage will not exceed 50 deg. C. on any part except the commutator, which will not exceed 65 deg. C. For 115 volt operation, semi-enclosed and all enclosed non-ventilated ratings are slightly reduced in horse-power output (compared to open ratings). When such motors are required, application should be made to the General Electric Co. All Type "RC" motors are capable of 50% momentary overload.

## Industrial Control for Stationary Motors

Space prevents listing but a limited assortment of GE Industrial Control Accessories for stationary motors. Customers should, in any case of doubt regarding proper selection, refer inquiry to the GE Industrial Control Department. We are ready at all times to assist in such inquiries.

## Control for AC Motor Circuits



CR-1038 Starting Switch
(For throwing small AC motors directly on the line)

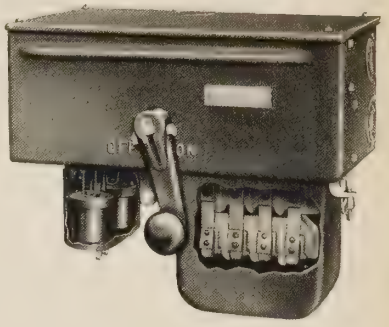
Involves excellent safety features, e. g., pulling *out* the handle *closes* the switch, therefore accidental closing by pushing or leaning on the handle is impossible.

For single-phase motors, 60 cycle, 110 volt, 1½ HP and below; 220 volt, 3 HP and below.

For two- or three-phase motors, 110/220/440/550 volt, 60, 40 and 25 cycle, 1/4 to 5 HP.

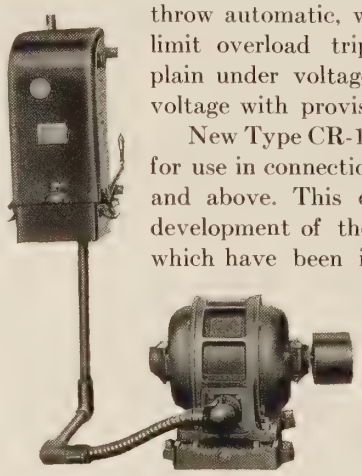
The CR-1038 switch consists of a triple or four pole (for single-phase motors connections to the middle switch blades are omitted) single throw, quick make and break switch, and two special receptacles for the protective plugs. The switch is mounted upon a base and totally enclosed in a sheet steel case with operating handle projecting through the front. Switch is arranged for conduit wiring. Padlock can be provided to lock switch in open position.

Small—Compact—Inexpensive—Substantial. Breakers may be provided with padlock for locking in open position. No exposed live parts.



Type FP-10 Circuit Breaker
For starting single or polyphase induction motors (Single-phase motors 110 volt, 3 HP and smaller; 220 volt, 5 HP and smaller; polyphase motors 25 HP and under.)

Type FP-10 oil circuit breakers are triple or four pole (for single-phase motors use triple pole breaker, leaving middle pole disconnected) single throw, non-automatic; triple or four pole single throw automatic, with double series inverse time limit overload trip; triple pole, single throw plain under voltage circuit breakers; and under voltage with provision for protective plugs.



CR-1034 Compensator with Conduit Connection to Induction Motor

New Type CR-1034 compensators are designed for use in connection with induction motors 5 HP and above. This compensator is an advanced development of the CR-1034 Forms H and J, which have been in successful operation many years. The principal refinements in the new CR-1034 are pressed steel covers in place of cast iron covers (a desirable feature especially for wall mounting), overload relays and no voltage-release; enclosed inside compensator case; emergency stop button on the outside of compensator case.

## Industrial Control for DC Motor Circuits

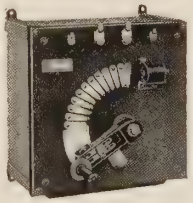


Fig. 9

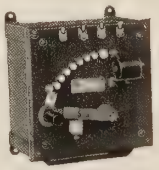
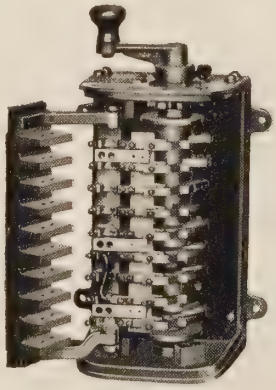
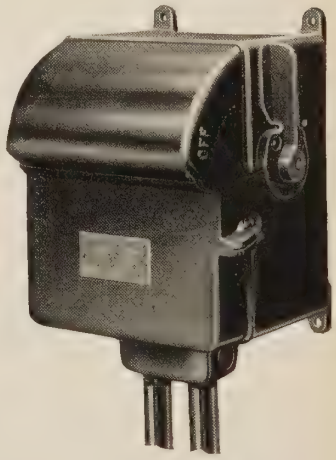


Fig. 10

Type CR-1000 Hand-Operated Starting Rheostats
For DC motors, ⅛ to 150 HP—all commercial voltages



Type CR-3100 Controller—cover removed. Typical Drum Controller for frequent starting duty, 5 to 75 H.P., 230 volts

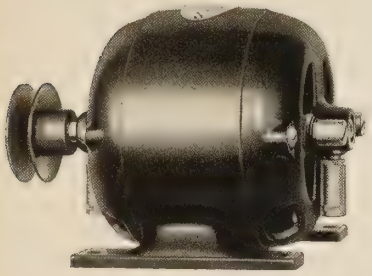


Type CR-4015 Starter with Conduit Box
Automatic Starter for DC motors—115 volts, 3 H.P. and smaller for 230 volts, 5 H.P., and smaller

# FRACTIONAL HORSE-POWER MOTORS

These small power motors combine at once a compact, attractive and sturdy mechanical design with high electrical efficiency. Both AC and DC types are readily adaptable for belted, geared or direct connection to the driven machine.

## TYPE SA MOTORS



Type SA, 325 Frame, 1/20 H. P., 1725 R. P. M., 60 Cycle Wick-Oiled Bearing Motor

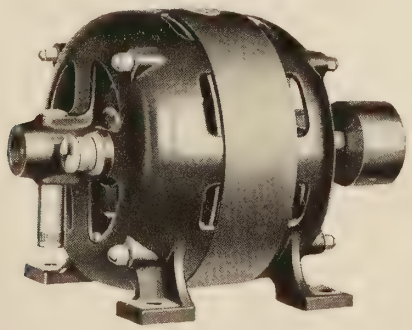
Type SA single-phase induction motors differ from the conventional design of induction motors in that the squirrel cage or secondary is made the stationary member and the rotor the primary element. This type of design together with the skeleton frame design used in Type SA motors offer many advantages such as minimum weight for maximum capacity, better ventilation, hence lower operating temperatures, smaller physical dimensions and greater accessibility for inspection.

Type SA motors are made in sizes 1-12 HP to ¼ HP inclusive, and are being successfully used for a very large number of motor applications requiring a motor of constant speed and a starting and maximum torque not in excess of 200% of normal full load torque.

## CONSTRUCTION

The stator or squirrel cage is made up of a number of thin laminations of electrical sheet steel firmly riveted together between heavy copper end rings. The copper rivets used for riveting the laminations together form the electrical circuits of the secondary.

The rotor or primary element is made of thin laminations pressed directly on to the shaft under hydraulic pressure—the winding is machine wound directly into the slots, and held firmly in place with slot wedges. The whole element is thoroughly dipped into insulating compound and carefully baked



Type SA, 147 Frame, ¼ H. P., 1725 R. P. M., 60 Cycle Wick-Oiled Bearing Motor

to insure thorough insulation. The shafts are made of the best quality of steel and are carefully ground to accurate size.

The cast iron end flanges carrying the bearings are carefully finished and accurately machined to insure perfect alignment of the bearings and uniform air gap.

The bearings are made of the highest grade phosphor bronze bearing metal and are of the straight sleeve type pressed into the bearing housings. Bearings are carefully aligned by reaming in place, thus securing perfect bearing fits.

Metal caps and rings fitted tightly in the bearing housings make the bearings practically dust-proof.

Proper lubrication is secured by means of wick-fed grease cups on all frames. The cups are filled at the factory before shipment. In refilling grease cups use Keystone grease No. 4 or a good grade of unmedicated vaseline.

The rotor carrying the primary winding is connected to the line circuit through two binding posts carrying brushes which bear on a collector ring or disk. On the back of the collector ring is mounted the automatic centrifugal switch which opens the circuit to the starting winding when the motor is nearly up to speed.

All Type SA motors are carefully tested and inspected before shipping and are guaranteed for one year against defects in material or labor.

## MECHANICAL INTERCHANGEABILITY

A feature of advantage to the manufacturer of motor driven devices is the fact that the general dimensions of Type SA motors and the corresponding Type SD direct current motors are the same. This feature enables the manufacturer to furnish his machines with either AC or DC motors without extra machine work or fittings.

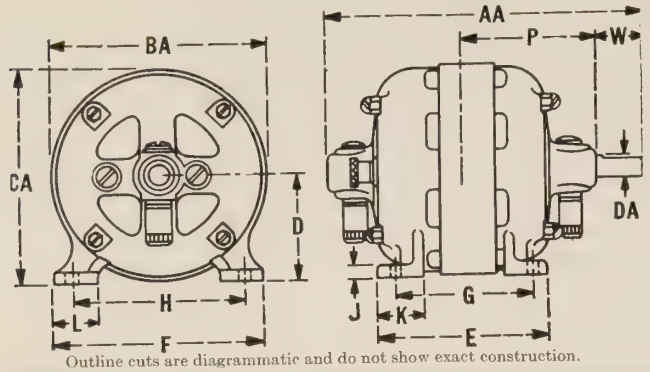
### TYPE SA, ALTERNATING CURRENT

60 CYCLES, SINGLE-PHASE

| H.P. | Full Load Speed RPM | VOLTS | Model Nos. | Clutch-less | Ship. Wt. in Lb. (Approx.) | Standard Pulley Dimensions in In. | | Cat. No. of Pulley | Frame No. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Diam. at Belt Center | Adapted to Round Belt Diam. | | |
| **150 PER CENT. START (i. e., 50 PER CENT. OVERLOAD) Continuous Service 1800 R.P.M. Synchronous** | | | | | | | | | |
| 1/20 | 1725 | 110 | 20005 | | 20 | 1¼ | 3/16 | 191204 | 325 |
| 1/20 | 1725 | 220 | 20006 | | 20 | 1¼ | 3/16 | 191204 | 325 |
| 1/12 | 1725 | 110 | 20007 | | 24 | 1⅜ | ¼ | 191213 | 135 |
| 1/12 | 1725 | 220 | 20008 | | 24 | 1⅜ | ¼ | 191213 | 135 |
| 1/8 | 1725 | 110 | 20009 | | 26 | 1⅞ | ¼ | 191215 | 137 |
| 1/8 | 1725 | 220 | 20010 | | 26 | 1⅞ | ¼ | 191215 | 137 |
| 1/4 | 1725 | 110 | 20011 | | 36 | *2½ | *1¼ | 204389 | 147 |
| 1/4 | 1725 | 220 | 20012 | | 36 | *2½ | *1¼ | 204389 | 147 |
| **150 PER CENT. START (i. e., 50 PER CENT. OVERLOAD) Continuous Service 1200 R.P.M. Synchronous** | | | | | | | | | |
| 1/12 | 1140 | 110 | 20017 | | 26 | 1⅞ | ¼ | 191215 | 137 |
| 1/12 | 1140 | 220 | 20018 | | 26 | 1⅞ | ¼ | 191215 | 137 |
| 1/6 | 1140 | 110 | 20019 | | 36 | *2½ | *1¼ | 204389 | 147 |
| 1/6 | 1140 | 220 | 20020 | | 36 | *2½ | *1¼ | 204389 | 147 |

*Pulley for Frame 147 has crowned face adapted for flat belt. Dimensions given for this frame are Pulley Diam. and Belt Width.
Feet on 325 frame cast integral with frame.
Feet on 135, 137 and 147 frames cast integral with end shields.
Model No. does not include pulley.

DIMENSIONS OF TYPE SA MOTORS



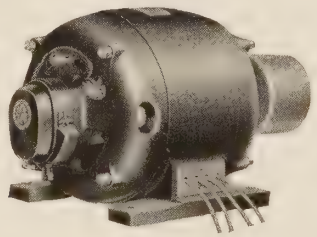

Outline cuts are diagrammatic and do not show exact construction.

| Frame | Net Wt. In Lb. SI | Dimensions in Inches AA | BA | CA | *D | DA | E | F | †G | †H | J | K | L | P | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 325 | 10½ | 6¾ | 4⅞ | 4 15/16 | 2½ | ⅜ | 4 ⅜ | 5 | 3 5/8 | 4 ¼ | 5/16 | 1 1/16 | .... | 2 ¾ | 1¼ |
| 135 | 14 | 8 3/16 | 5⅜ | 5 7/16 | 2¾ | ½ | 4 7/16 | 5 5/16 | 3 9/16 | 4 7/16 | 5/16 | 1 ⅛ | 1⅛ | 3 15/32 | 1¼ |
| 137 | 15¾ | 8 9/16 | 5⅜ | 5 7/16 | 2¾ | ½ | 4 13/16 | 5 5/16 | 3 15/16 | 4 7/16 | 5/16 | 1 ⅛ | 1⅛ | 3 21/32 | 1¼ |
| 145 | 19¾ | 8⅞ | 6 5/16 | 6 13/32 | 3¼ | ½ | 4 ½ | 6¼ | 3½ | 5 ¼ | 5/16 | 1 ¼ | 1¼ | 3 13/16 | 1¼ |
| 147 | 22 | 9¼ | 6 5/16 | 6 13/32 | 3¼ | ½ | 4 ⅞ | 6¼ | 3 7/8 | 5 ¼ | 5/16 | 1 ¼ | 1¼ | 4 | 1¼ |
| 149 | 27½ | 9¾ | 6 5/16 | 6 13/32 | 3¼ | ½ | 5 ⅜ | 6¼ | 4 3/8 | 5 ¼ | 5/16 | 1 ¼ | 1¼ | 4 ¼ | 1¼ |

*Dimension D is approximate. It will never exceed but may be 1/16 in. below that given.
†Dimensions G and H are approximate. They may vary 1/64 in. above or below those given.

## Type RSA Motors

Type RSA motors are constant speed high torque motors and are especially suited for such applications as pumps, compressors, coffee grinders and meat choppers, and other devices



Type RSA Motor

requiring very high starting and maximum torque with low starting current. They are built in sizes ranging from 1-12 HP to ¾ HP inclusive.

The RSA motor starts as a repulsion motor and at a predetermined speed, a centrifugal device short circuits the commutator and the motor then runs as an induction motor with induction motor characteristics. The brushes are fixed, that is they are not lifted from the commutator but carry current only when the motor is starting.

## Construction

The frames of all RSA motors are made of high grade cast iron and are made in one piece with the feet cast integrally. The end flanges carrying the bearings and oil reservoirs are held in place by four heavy through bolts.

The primary core is made up of thin laminations of electrical sheet steel punchings securely riveted together and firmly fastened within the main casting. The primary winding is wound directly into the core slots by automatic winding machines.

The secondary or armature core is made of laminations pressed directly on to the shaft under great pressure to insure against displacement. The commutator is built up of hard drawn copper segments carefully insulated and is of the well-known axial type.

## Short Circuiting Mechanism

This device is very simple and positive in action. A copper disk is pressed against the end of the commutator at a predetermined speed, short circuiting it and causing the motor to run as an induction motor.

The end flanges are very strong and rigid and are bolted to the main frame casting with four *through bolts*.

Ring oil bearings are used on all sizes of RSA motors. Four leads are brought out from the motor frame and are arranged for interchanging for either 110 or 220 volt operation.

RSA motors have a starting torque of 200–300% of full load torque with full line voltage and a maximum torque of 200% of full load. The starting current is approximately three times full load normal running current.

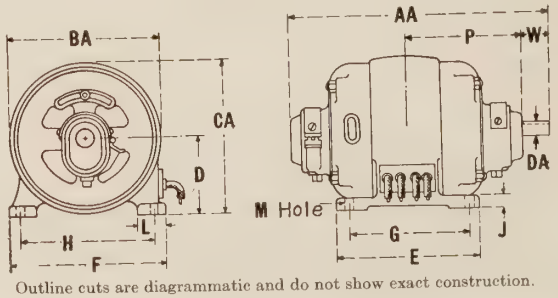
RSA motors are fully guaranteed against defects in material and labor.

TYPE RSA OIL RING BEARING
60 AND 25 CYCLES, SINGLE-PHASE

| H.P. | Full Load Speed | *Model No. | Ship. Wt. in Lb. (Approx.) | Standard Pulley Dimensions in In. Dia. | Belt Width | Bore | Cat. No. of Pulley | Full Load Efficiency | Full Load Power-Factor | Full Load Amps. 220 Volts | Frame |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 CYCLES | | | | | | | | | | | |
| 1/12 | 1140 | 20081 | 35 | 2 | †5/16 | ½ | 191215 | 39 | 56 | 1.3 | 435 |
| ⅛ | 1725 | 20077 | 35 | 2 | †5/16 | ½ | 191215 | 47 | 57 | 1.6 | 435 |
| 1/6 | 1140 | 20082 | 45 | 2½ | 1 | ⅝ | 191678 | 46 | 53 | 2.3 | 445 |
| ¼ | 1725 | 20078 | 45 | 2½ | 1 | ⅝ | 191678 | 64 | 70 | 1.9 | 445 |
| ⅓ | 1140 | 20083 | 70 | 3½ | 2 | ¾ | ..... | 56 | 58 | 3.5 | 455 |
| ½ | 1725 | 20079 | 70 | 3½ | 2 | ¾ | ..... | 65 | 75 | 3.5 | 455 |
| ½ | 1140 | 20084 | 90 | 3½ | 2 | ¾ | ..... | 60 | 63 | 4.2 | 465 |
| ¾ | 1725 | 20080 | 90 | 3½ | 2 | ¾ | ..... | 68 | 80 | 4.7 | 465 |
| 25 CYCLES | | | | | | | | | | | |
| ⅛ | 1425 | 20085 | 50 | 2 | †5/16 | ½ | 191215 | 47 | 60 | 1.5 | 439 |
| ¼ | 1425 | 20086 | 65 | 2½ | 1 | ⅝ | 191678 | 55 | 62 | 2.4 | 449 |
| ½ | 1425 | 20087 | 70 | 3½ | 2 | ¾ | ..... | 64 | 68 | 3.9 | 459 |
| ¾ | 1425 | 20088 | 110 | 3½ | 2 | ¾ | ..... | 65 | 72 | 5.3 | 469 |

*Model number does not include pulley.
†This size has pulley adapted for 5/16-in. round belt, all other sizes have crowned face pulley adapted for flat belt.

TYPE RSA MOTORS
DIMENSIONS




Outline cuts are diagrammatic and do not show exact construction.

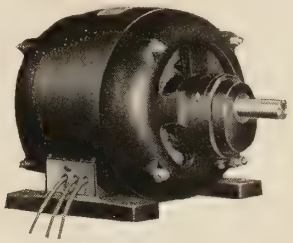
| Frame | Net Wt. | Dimensions in Inches AA | BA | CA | *D | DA | E | F | †G | †H | J | L | M | P | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 435 | 24 | 10 23/32 | 5 7/8 | 5 15/16 | 3 | ½ | 5 11/16 | 6⅛ | 4 11/16 | 5⅛ | ⅜ | 1¼ | 11/32 | 4 47/64 | 1¼ |
| 439 | 34 | 12 23/64 | 5 7/8 | 5 15/16 | 3 | ½ | 7 21/64 | 6⅛ | 6 21/64 | 5⅛ | ⅜ | 1¼ | 11/32 | 5 9/16 | 1¼ |
| 445 | 33 | 12 7/8 | 6 13/16 | 6 27/32 | 3 7/16 | ⅝ | 6 ⅜ | 7 | 5 ⅜ | 6 | ½ | 1¼ | 11/32 | 5 7/16 | 2 |
| 449 | 48 | 14 11/32 | 6 13/16 | 6 27/32 | 3 7/16 | ⅝ | 7 27/32 | 7 | 6 27/32 | 6 | ½ | 1¼ | 11/32 | 6 11/64 | 2 |
| 455 | 51 | 14 3/16 | 7 13/16 | 7 29/32 | 4 | ¾ | 7 7/16 | 7¾ | 6 5/16 | 6⅝ | ⅝ | 1½ | 13/32 | 6 3/32 | 2 |
| 459 | 69 | 15 15/32 | 7 13/16 | 7 29/32 | 4 | ¾ | 8 23/32 | 7¾ | 7 19/32 | 6⅝ | ⅝ | 1½ | 13/32 | 6 47/64 | 2 |
| 465 | 72 | 14 ¾ | 8 15/16 | 9 3/32 | 4 ⅝ | ¾ | 8 ¼ | 9 | 6 ¼ | 7 | ¾ | 2 | 17/32 | 6 ⅜ | 2 |
| 469 | 95 | 16 ½ | 8 15/16 | 9 3/32 | 4 ⅝ | ¾ | 9 17/32 | 9 | 7 17/32 | 7 | ¾ | 2 | 17/32 | 7 ⅛ | 2 |

*Dimension D is approximate. It will never exceed, but may be 1/16 in. below that given.
†Dimensions G and H are approximate. They may vary 1/64 in. above or below those given

# Type RKT and RKQ Motors

(Three-Phase and Two-Phase)

RKT and RKQ polyphase motors have been designed to meet the demand for fractional HP motors for service on polyphase circuits. They are built in sizes ranging from 1/8 HP to 1/2 HP inclusive, 25 cycles and 60 cycles. They closely resemble the RSA line in general appearance and external construction.



Type RKT, Oil Ring Bearing Motor

The main frame casting is made of cast iron and is machined to receive the stator core and end flanges carrying the bearings.

The primary core is made up of a number of thin laminations riveted together and securely fastened into the main frame casting.

The primary winding is form wound and is placed into the core slots and firmly held in place by fiber slot wedges. The whole primary structure is dipped in insulating compound and thoroughly baked to insure perfect insulation.

The rotor is of the squirrel cage type. Copper bars pass through the core slots and are securely riveted over at the ends, holding the short circuiting rings and laminations together firmly.

The bearing brackets are held in place by four through bolts. In frame 335, one bearing bracket is cast integral with the main frame casting.

The bearings are of the well-known oil ring type, except frame 335, which has wick oilers.

Leads are brought out through suitable bushings in the main frame for connection to supply circuit.

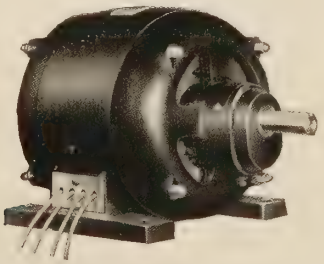
## Lubrication

On the frame 335, wick oilers are furnished and non-fluid grease should be used, while in the ring oil type only high cylinder oil should be used.

## Guarantees

Type RKQ and RKT motors carry the standard guarantees given all G-E Fractional HP Motors of light duty type.

The temperature rise will not exceed 40 degrees C. on all parts based on full load continuously. The motors will carry an overload of 25%, for one-half hour without serious injury. All temperatures are based on an ambient temperature of 40 degrees.



Type RKQ, Oil Ring Bearing Motor

### TYPE RKT, 3-PHASE AND TYPE RKQ, 2-PHASE

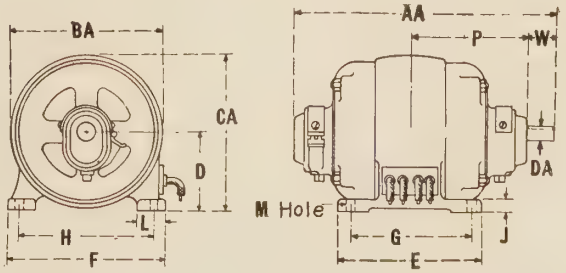
60 AND 25 CYCLES

| H.P. | Full Load Speed RPM | Volts | †Model No. Motor Only | Ship. Wt. in Lb. (Approx.) | Pulley Dimensions in In. | | | Cat. No. of Pulley | Frame No. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Dia. | Belt Width | Bore | | |
| **60 CYCLES—1725 R.P.M.** | | | | | | | | | |
| 1/8 | 1725 | 110 | 20089 | 25 | *1 7/8 | *1/4 | 1/2 | 191215 | ‡335 |
| 1/8 | 1725 | 220 | 20090 | 25 | *1 7/8 | *1/4 | 1/2 | 191215 | ‡335 |
| 1/4 | 1725 | 110 | 20091 | 35 | 2 1/2 | 1 1/4 | 1/2 | 204389 | 435 |
| 1/4 | 1725 | 220 | 20092 | 35 | 2 1/2 | 1 1/4 | 1/2 | 204389 | 435 |
| 1/4 | 1725 | 440 | 20093 | 35 | 2 1/2 | 1 1/4 | 1/2 | 204389 | 435 |
| 1/2 | 1725 | 110 | 20094 | 45 | 3 1/2 | 2 | 5/8 | ..... | 445 |
| 1/2 | 1725 | 220 | 20095 | 45 | 3 1/2 | 2 | 5/8 | ..... | 445 |
| 1/2 | 1725 | 440 | 20096 | 45 | 3 1/2 | 2 | 5/8 | ..... | 445 |
| **60 CYCLES—1140 R.P.M.** | | | | | | | | | |
| 1/12 | 1140 | 110 | 20097 | 25 | *1 7/8 | *1/4 | 1/2 | 191215 | ‡335 |
| 1/12 | 1140 | 220 | 20098 | 25 | *1 7/8 | *1/4 | 1/2 | 191215 | ‡335 |
| 1/6 | 1140 | 110 | 20099 | 35 | 2 1/2 | 1 1/4 | 1/2 | 204389 | 435 |
| 1/6 | 1140 | 220 | 20100 | 35 | 2 1/2 | 1 1/4 | 1/2 | 204389 | 435 |
| 1/3 | 1140 | 110 | 20101 | 45 | 3 1/2 | 2 | 5/8 | ..... | 445 |
| 1/3 | 1140 | 220 | 20102 | 45 | 3 1/2 | 2 | 5/8 | ..... | 445 |
| **25 CYCLES—1425 R.P.M.** | | | | | | | | | |
| 1/8 | 1425 | 110 | 20103 | 35 | *1 7/8 | *1/4 | 1/2 | 191215 | 435 |
| 1/8 | 1425 | 220 | 20104 | 35 | *1 7/8 | *1/4 | 1/2 | 191215 | 435 |
| 1/4 | 1425 | 110 | 20105 | 50 | 2 1/2 | 1 1/4 | 1/2 | 204389 | 439 |
| 1/4 | 1425 | 220 | 20106 | 50 | 2 1/2 | 1 1/4 | 1/2 | 204389 | 439 |
| 1/2 | 1425 | 110 | 20107 | 60 | 3 1/2 | 2 | 5/8 | ..... | 449 |
| 1/2 | 1425 | 220 | 20108 | 60 | 3 1/2 | 2 | 5/8 | ..... | 449 |

*Indicates "V" groove pulley adapted to round belt.
†Model number does not include pulley and covers open type motor only.
‡Frame 335 has wick-oiled bearings.

### TYPE RKT AND RKQ MOTORS

DIMENSIONS




Outline cuts are diagrammatic and do not show exact construction.

| Frame | Net Wt. inLb. | Dimensions in Inches | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AA | BA | CA | *D | DA | E | F | †G | †H | J | L | M | P | W |
| 335 | 15 | 7 7/8 | 5 7/8 | 5 15/16 | 3 | 1/2 | 4 15/16 | 6 1/8 | 3 15/16 | 5 1/8 | 5/16 | 1 1/4 | 11/32 | 3 5/16 | 1 1/4 |
| 435 | 23 | 10 23/32 | 5 7/8 | 5 15/16 | 3 | 1/2 | 5 11/16 | 6 1/8 | 4 11/16 | 5 1/8 | 3/8 | 1 1/4 | 11/32 | 4 47/64 | 1 1/4 |
| 439 | 33 | 12 23/64 | 5 7/8 | 5 15/16 | 3 | 1/2 | 7 21/64 | 6 1/8 | 6 21/64 | 5 1/8 | 3/8 | 1 1/4 | 11/32 | 5 9/16 | 1 1/4 |
| 445 | 32 | 12 7/8 | 6 13/16 | 6 27/32 | 3 7/16 | 5/8 | 6 3/8 | 7 | 5 3/8 | 6 | 1/2 | 1 1/4 | 11/32 | 5 7/16 | 2 |
| 449 | 47 | 14 11/32 | 6 13/16 | 6 27/32 | 3 7/16 | 5/8 | 7 27/32 | 7 | 6 27/32 | 6 | 1/2 | 1 1/4 | 11/32 | 6 11/64 | 2 |

*Dimension D is approximate. It will never exceed; but may, on Frame 335, be 1/32 in. below that given, or on Frames 435 and larger, 1/16 in. below that given.

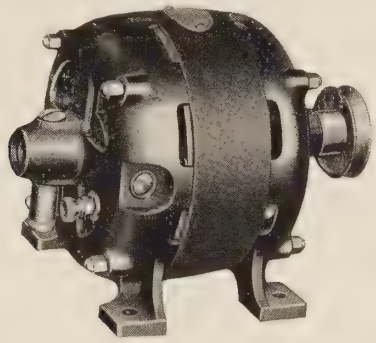
†Dimensions G and H are approximate. They may vary 1/64 in. above or below those given.

# Type SD Motors

Type SD motors have been designed to meet the demands for motors to operate on direct current. They are mechanically interchangeable with corresponding ratings of the Type SA line, and possess all the salient features of design and operation of the SA line.

## CONSTRUCTION

The field frame or core is made up of a number of comparatively thick punchings firmly riveted together; the poles being an integral part of the punchings.



Type SD, 1/8 H.P., 1725 R.P.M. Motor with Wick-Oiled Bearings

The field coils are form wound and are carefully taped and dipped in insulating compound and thoroughly baked. They are then put in place and fixed on the pole pieces.

The end flanges, frames 234 to 256 inclusive have the feet cast integrally. Frame 325 has a solid cast iron frame very similar to those of the SDA line, while frame 264 has a separable base casting which is fastened to the field ring with four heavy cap screws.

Wick oilers are used on all frames, except frame 264, which has ring oil bearings.

The armature core punchings are pressed directly on to the shaft under hydraulic pressure insuring very solid construction.

The bearings are of the highest grade, phosphor bronze bearing metal procurable.

The brushholders on all frames are of the well-known cartridge type; on motors rated 1/8 HP and above, shunted brush springs are used.

## STARTING TORQUE AND CURRENT

SD compound motors, 1/2 HP and below (without starting rheostat) 300-400% of full load torque with four to five times full load current.

Type SD, 1/2 H.P., 1140 R.P.M. Motor with Oil Ring Bearings

SD shunt motors, 1-12 HP or below (without starting rheostat) 200-300% of full load torque, with four to five times full load current. The maximum starting torque of SD motors of all ratings, when starting rheostats are used which may be expected with proper commutating stability, is 250% for shunt motors and 300% for compound wound motors.

Speed regulation is approximately 8–15% for shunt and 20–25% for compound wound motors.

## HEATING

Windings of standard direct current SD motors of open frame design will not exceed the following rises as measured by thermometer in degrees C., based on ambient temperature of 40 degrees C., full load continuously 40 degrees, 25% overload for one-half hour, 55 degrees. 50% momentary overload without injurious heating or sparking.

SD direct current motors will operate satisfactorily without excessive heating with line voltage variations not exceeding 10% above or below normal line voltages.

### TYPE SD CONTINUOUS SERVICE

### SHUNT AND COMPOUND WOUND

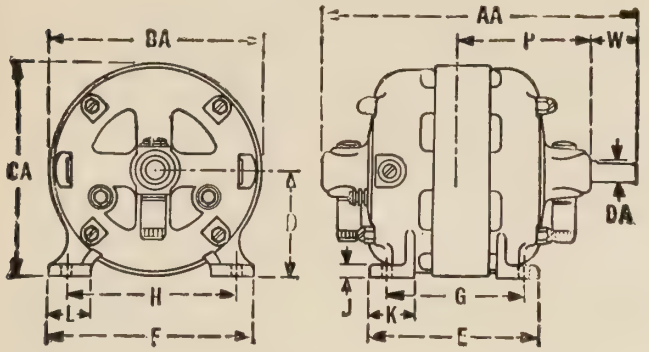
| H.P. | Rated Speed RPM | Volts | †Model No. Open Motor | Ship. Wt. in. Lb. (Approx.) | Standard Pulley Dimensions in In. | | | Cat. No. of Pulley | Frame No. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Diam. at Belt Center | Adapted to Round Belt Diam. | Bore | | |
| **SHUNT WOUND** | | | | | | | | | |
| 1/20 | 1725 | 110 | 20032 | 20 | 1¼ | 3/16 | 3/8 | 191204 | 325 |
| 1/20 | 1725 | 220 | 20034 | 20 | 1¼ | 3/16 | 3/8 | 191204 | 325 |
| 1/12 | 1725 | 110 | 20037 | 24 | 1⅜ | ¼ | ½ | 191213 | 234 |
| 1/12 | 1725 | 220 | 20038 | 24 | 1⅜ | ¼ | ½ | 191213 | 234 |
| **COMPOUND WOUND** | | | | | | | | | |
| 1/12 | 1140 | 110 | 20339 | 26 | 1⅞ | ¼ | ½ | 191215 | 236 |
| 1/12 | 1140 | 220 | 20040 | 26 | 1⅞ | ¼ | ½ | 191215 | 236 |
| 1/8 | 1725 | 110 | 20041 | 26 | 1⅞ | ¼ | ½ | 191215 | 236 |
| 1/8 | 1725 | 220 | 20042 | 26 | 1⅞ | ¼ | ½ | 191215 | 236 |
| 1/6 | 1140 | 110 | 20043 | 36 | *2½ | *1¼ | ½ | 204389 | 246 |
| 1/6 | 1140 | 220 | 20044 | 36 | *2½ | *1¼ | ½ | 204389 | 246 |
| 1/4 | 1725 | 110 | 20045 | 36 | *2½ | *1¼ | ½ | 204389 | 246 |
| 1/4 | 1725 | 220 | 20046 | 36 | *2½ | *1¼ | ½ | 204389 | 246 |
| 1/3 | 1140 | 110 | 20047 | 50 | *3½ | *2 | 5/8 | ..... | 256 |
| 1/3 | 1140 | 220 | 20048 | 50 | *3½ | *2 | 5/8 | ..... | 256 |
| 1/2 | 1725 | 110 | 20049 | 50 | *3½ | *2 | 5/8 | ..... | 256 |
| 1/2 | 1725 | 220 | 20050 | 50 | *3½ | *2 | 5/8 | ..... | 256 |
| 1/2 | 1140 | 110 | 20051 | 80 | *3½ | *2 | ¾ | ..... | 264 |
| 1/2 | 1140 | 220 | 20052 | 80 | *3½ | *2 | ¾ | ..... | 264 |
| 3/4 | 1725 | 110 | 20053 | 80 | *3½ | *2 | ¾ | ..... | 264 |
| 3/4 | 1725 | 220 | 20054 | 80 | *3½ | *2 | ¾ | ..... | 264 |

*Pulleys for Frames 246 and larger have crowned face adapted for flat belt. Dimensions given for these frames are Pulley Diam. and Belt Width.

†Model No. does not include pulley.

△Frames 325 to 256 inclusive have wick-oiled bearings. Frame 264 has oil-ring bearings and removable foot casting.

DIMENSIONS OF TYPE SD MOTORS




Outline cuts are diagrammatic and do not show exact construction.

| Frame | Wt. in Lb. | Dimensions in Inches | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AA | BA | CA | *D | DA | E | F | †G | †H | J | K | L | P | W |
| 325 | 10½ | 6 ¾ | 4⅞ | 4 15/16 | 2 ½ | ⅜ | 4 ⅜ | 5 | 3 ⅝ | 4 ¼ | 5/16 | . . . | 1 1/16 | 2 ¾ | 1¼ |
| 334 | 13¼ | 8 3/16 | 5⅝ | 5 7/16 | 2 ¾ | ½ | 4 7/16 | 5 5/16 | 3 9/16 | 4 7/16 | 5/16 | 1⅛ | 1⅛ | 3 15/32 | 1¼ |
| 336 | 14¾ | 8 9/16 | 5⅜ | 5 7/16 | 2 ¾ | ½ | 4 13/16 | 5 5/16 | 3 15/16 | 4 7/16 | 5/16 | 1⅛ | 1⅛ | 3 21/32 | 1¼ |
| 344 | 18¾ | 8 ⅞ | 6 5/16 | 6 13/32 | 3 ¼ | ½ | 4 ½ | 6 ¼ | 3 ½ | 5 ¼ | 5/16 | 1¼ | 1¼ | 3 13/16 | 1¼ |
| 346 | 20¾ | 9 ¼ | 6 5/16 | 6 13/32 | 3 ¼ | ½ | 4 ⅞ | 6 ¼ | 3 ⅞ | 5 ¼ | 5/16 | 1¼ | 1¼ | 4 | 1¼ |
| 356 | 36 | 11 19/32 | 7⅜ | 7 ½ | 3 13/16 | ⅝ | 6 21/32 | 7 ⅜ | 5 17/32 | 6 ¼ | ⅜ | 1½ | 1½ | 5 11/64 | 1¼ |
| 364 | 63 | 13 ¾ | 8¾ | 9 ¼ | 4 ⅞ | ¾ | 7 ¾ | 9 | 5 ¾ | 7 | ¾ | 2 | 2 | 5 ⅞ | 2 |

*Dimension D is approximate. It will never exceed, but may be 1/16 in. below that given.
†Dimensions G and H are approximate. They may be 1/64 in. above or below those given.

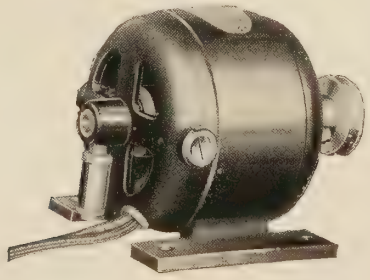
## Type SDA Motors

Type SDA motors are built in five sizes, 1-200 HP to 1-15 HP, Speeds 1800 or 2200 RPM, 110 and 220 volts, 60 cycles, except frame 300, which is wound for 110 volts only.

The field laminations are held in a cast iron case, which has the feet cast integral with the main frame casting. The pulley end bearing bracket is separable, being held in place by two stud bolts screwed into the main frame casting, so the motor may be readily dismantled for inspection.

The bearings are the usual straight sleeve phosphor bronze type with standard wick oiler on all frames except frame 300 in which a felt retainer is used.

The brushes are of the well-known cartridge type and are placed in a fixed position in the motor frame casting.



Type SDA-315 Frame, 1/50 h.p.—1800 r.p.m., 60 Cycles, 110 v.

All type SDA motors are furnished with 18-inch leads, brought out through a rubber bushing. "V" Groove pulleys, suitable for round belts are regularly furnished.

TYPE SDA, FORM A, ALTERNATING CURRENT
60 CYCLES, SERIES WOUND

| H.P. | Speed Full Load RPM | Volts | *Model No. | Ship. Wt. in Lb. (Approx.) | Std. Pulley Dimensions in In. | | Cat. No. of Pulley | Full Load Amperes | Watts Input | Frame No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Diam. at Belt Center | Adapted to Round Belt Diam. | | | | |
| 1/200 | 2200 | 110 | 20060 | 6 | ⅝ | ⅛ | 190407 | 0.2 | 15 | 300 |
| 1/200 | 2200 | 220 | † | .. | .. | .... | ..... | .. | .. | ... |
| 1/100 | 2200 | 110 | 20061 | 8 | ⅝ | ⅛ | 190407 | 0.36 | 25 | 305 |
| 1/100 | 2200 | 220 | 20062 | 8 | ⅝ | ⅛ | 190407 | 0.18 | 25 | 305 |
| 1/50 | 1800 | 110 | 20063 | 13 | 1¼ | 3/16 | 190536 | 0.8 | 55 | 315 |
| 1/50 | 1800 | 220 | 20064 | 13 | 1¼ | 3/16 | 190536 | 0.4 | 55 | 315 |
| 1/25 | 1800 | 110 | 20065 | 20 | 1¼ | 3/16 | 191204 | 1.4 | 95 | 325 |
| 1/25 | 1800 | 220 | 20066 | 20 | 1¼ | 3/16 | 191204 | 0.7 | 95 | 325 |
| 1/15 | 1800 | 110 | 20067 | 25 | 1¼ | 3/16 | 191213 | 2.0 | 130 | 335 |
| 1/15 | 1800 | 220 | 20068 | 25 | 1¼ | 3/16 | 191213 | 1.0 | 130 | 335 |

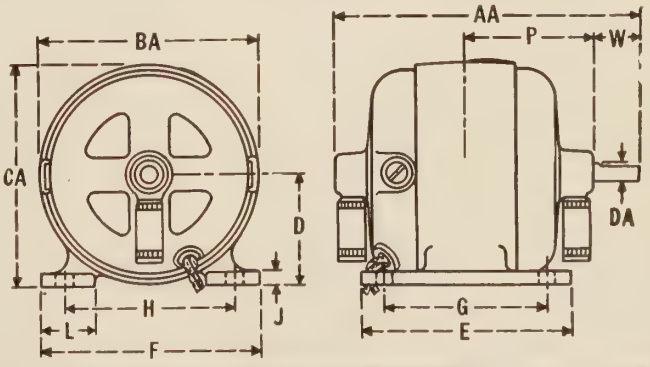
*Model No. does not include pulley. †Use 110-volt motor with proper resistance in series

TYPE SDA, FORM D, DIRECT CURRENT
SERIES WOUND

| H.P. | Speed Full Load RPM | Volts | Model No. (Not including pulley) | Ship. Wt. in Lb. (Approx.) | Std. Pulley Dimensions in In. | | Cat. No. of Pulley | Full Load Amperes | Watts Input | Frame No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Diam. at Belt Center | Adapted to Round Belt Diam. | | | | |
| 1/200 | 2200 | 110 | 20069 | 6 | ⅝ | ⅛ | 190407 | 0.13 | 15 | 300 |
| 1/200 | 2200 | 220 | † | .. | .. | .. | ..... | .. | .. | ... |
| 1/100 | 2200 | 110 | 20070 | 8 | ⅝ | ⅛ | 190407 | 0.18 | 25 | 305 |
| 1/100 | 2200 | 220 | † | .. | .. | .. | ..... | .. | .. | ... |
| 1/50 | 1800 | 110 | 20071 | 13 | 1¼ | 3/16 | 190536 | 0.37 | 41 | 315 |
| 1/50 | 1800 | 220 | 20072 | 13 | 1¼ | 3/16 | 190536 | 0.19 | 41 | 315 |
| 1/25 | 1800 | 110 | 20073 | 20 | 1¼ | 3/16 | 191204 | 0.72 | 80 | 325 |
| 1/25 | 1800 | 220 | 20074 | 20 | 1¼ | 3/16 | 191204 | 0.36 | 80 | 325 |
| 1/15 | 1800 | 110 | 20075 | 25 | 1¼ | 3/16 | 191213 | 0.92 | 100 | 335 |
| 1/15 | 1800 | 220 | 20076 | 25 | 1¼ | 3/16 | 191213 | 0.46 | 100 | 335 |

† Use 110-volt motor with proper resistance in series.

DIMENSIONS OF TYPE SDA MOTORS




| Frame | Net Wt. in Lb. | Dimensions in Inches | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AA | BA | CA | *D | DA | E | F | †G | †H | J | L | P | W |
| ‡300 | 2 | 4 1/8 | 2 15/16 | 2 31/32 | 1 ½ | 7/32 | 2 7/8 | 2 15/16 | 2 ⅛ | 2 3/16 | 3/16 | ¾ | 1 47/64 | 21/32 |
| 305 | 4 | 4½ | 3 ½ | 3 9/16 | 1 13/16 | 7/32 | 3 ¼ | 3 9/16 | 2 ½ | 2 13/16 | 7/32 | ⅞ | 1 59/64 | 21/32 |
| 315 | 5⅜ | 5⅝ | 4 | 4 1/16 | 2 1/16 | 5/16 | 3 7/8 | 4 1/16 | 3 | 3 3/16 | ¼ | 1 | 2 ⅜ | ⅞ |
| 325 | 10½ | 6¾ | 4 7/8 | 4 15/16 | 2 ½ | ⅜ | 4 ⅜ | 5 | 3 5/8 | 4 ¼ | 5/16 | 1 1/16 | 2 ¾ | 1 ¼ |
| 335 | 15¾ | 7⅞ | 5 ⅞ | 5 15/16 | 3 | ½ | 4 15/16 | 6 ⅛ | 3 15/16 | 5 ⅛ | 5/16 | 1 ¼ | 3 5/16 | 1 ¼ |

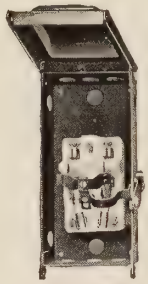
*Dimension D is approximate. It will never exceed, but may be 1/32 in. below that given.
†Dimensions G and H are approximate They may vary 1/64 in. above or below those given.
‡Frame 300 furnished with felt oil retainers instead of oil cups as shown.

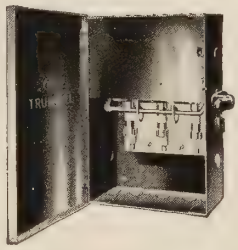
# TRUMBULL SAFETY SWITCHES

## A Complete Line

Entrance Switch
125v

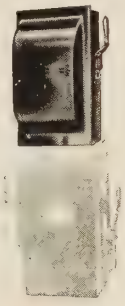
No Fuse
Double Throw


Porcelain Base
250v N.E.C.S.


Fusible Switch
with Shield

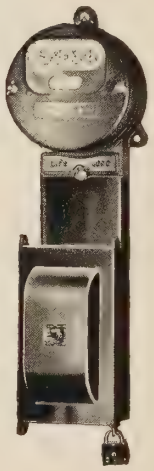
Quick Make and
Quick Break

Entrance Switch
Box Closed

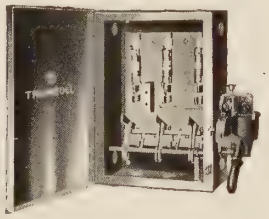

Compensator
Switch

Fusible
30-1200 Amp.

No Fuse
Single Throw


Entrance Switch with
Meter Trim

Motor Reversing
Switch


Motor Starting
with U.V.R. Coil

Motor Starting
with Shield

THE outstanding features of these Safety Switches are:—

I. All switches used are Type "A", machine-made, built-up switches. Punched clip switches not used.

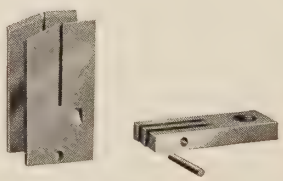
II. Box cannot be opened until switch is in "off" position.

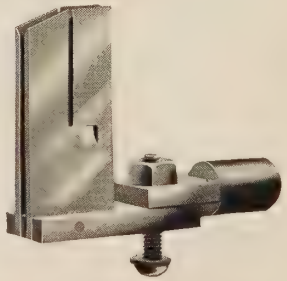
III. Switch cannot be closed until cover is down, except as the "catch" is manipulated by expert when necessary to examine the switch under load with box open.

Safety Switches represent the modern development of the old open switch and eventually will supplant them in all installations.

Trumbull general catalog lists a complete line of Safety Switches. Pettingell-Andrews Company will send catalog upon request, also pocket bulletin of Safety Switches can be supplied to all interested.

### Built-up Contact Jaws


Footblock milled
Blades sweated and pinned into footblocks, giving a mechanical and electrical strength that cannot be obtained in the Punched Clip type of Contact Jaws


Contact Clip complete
Switch Blades are "ground in" where they enter Contact Jaws

## NEW ENGLAND DISTRIBUTORS

Thor

ELECTRIC

WASHING MACHINES, IRONING MACHINES, VACUUM CLEANERS

AND HURLEY SOAP

# EDISON ELECTRIC APPLIANCE CO.

### HOTPOINT

AUTO HEATERS
CURLING IRONS
"HEDLITE" HEATERS
GRILLS
IRONS
HEATING PADS
HOLLOW WARE
AND OTHER APPLIANCES

### HUGHES

HEAVY DUTY RANGES
BAKE OVENS
BROILERS
HOTEL TYPE TOASTERS
DOMESTIC RANGES
WATER HEATERS
HOT PLATES
AND OTHER APPLIANCES

### EDISON

SEWING MACHINES
ROTARY AND VIBRATORY TYPES
DOMESTIC RANGES
IRONS
TOASTERS
FURNACES
HOLLOW WARE
AND OTHER APPLIANCES

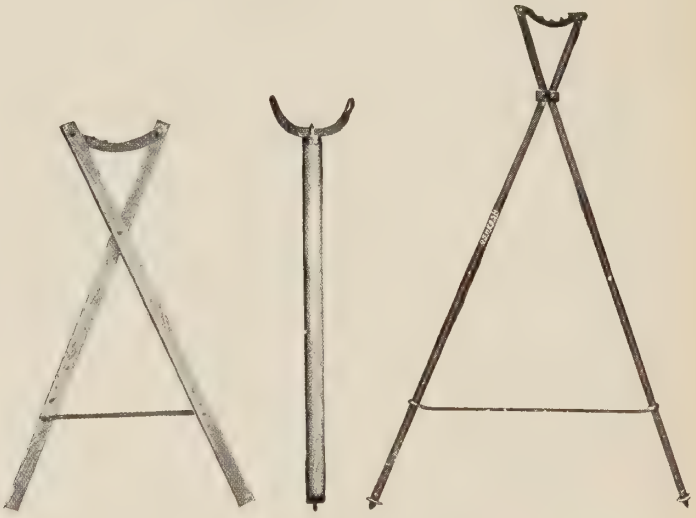
# CONSTRUCTION TOOLS

## A Complete Line Always in Stock

Send for Complete Catalog

Carrying or Lug Hooks
Regular Pattern

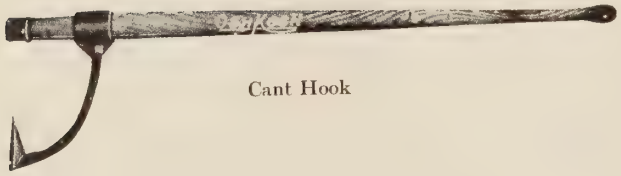
Western Union Pattern



Pole Supports

Jenney Type | Mule Type | Jenney Type

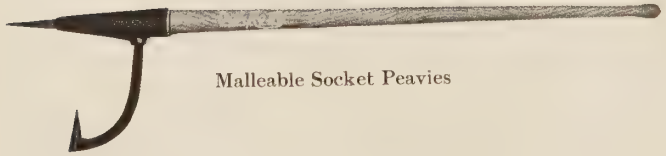
Tamping and Digging Bar



Cant Hook

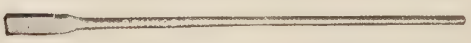
Crow and Digging Bar

Plain Digging Bar



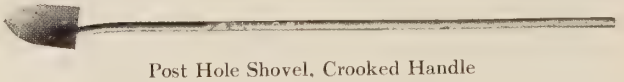
Malleable Socket Peavies

Loy or Slick



Tamping Bar with Heavy Iron Shoe

Guarded Pike Pole



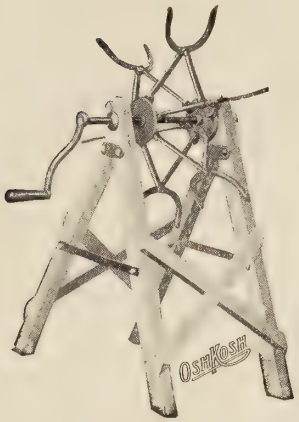
Post Hole Shovel, Crooked Handle

Post Hole Shovel, Straight Handle

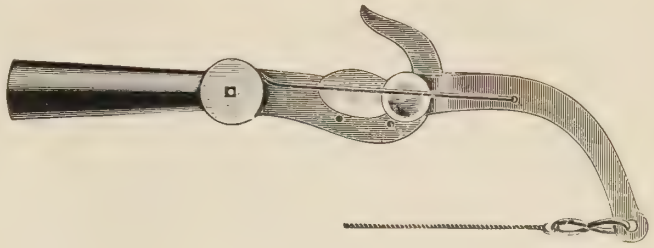
Pike Pole

Post Hole Spoon, Western Union Pattern

Barrow Reel




Take-up Reel



Tree Trimmer

Tree Trimmer with Saw

While only a few tools are shown here, Pettingell-Andrews Company carry in stock a complete line of all tools used in Pole Line Construction

| | | |
|---|---|---|
| Armor Cutters for BX | Linemen's Shields | Splicing Clamps |
| Buffalo Grips | Melting Pots | Speed Indicators |
| Come-alongs | Pouring Ladles | Soldering Irons, GE |
| Climbers | Pliers | Step Ladders |
| Climber Straps | Pole Counters | Torches |
| Climber Pads | Reamers | Vises |
| Conduit Benders | Rubber Gloves | Wire Cutters |
| Fire Pots | Safety Belts | Wire Gauges |

# "DELTABESTON"

## HEATER CORD

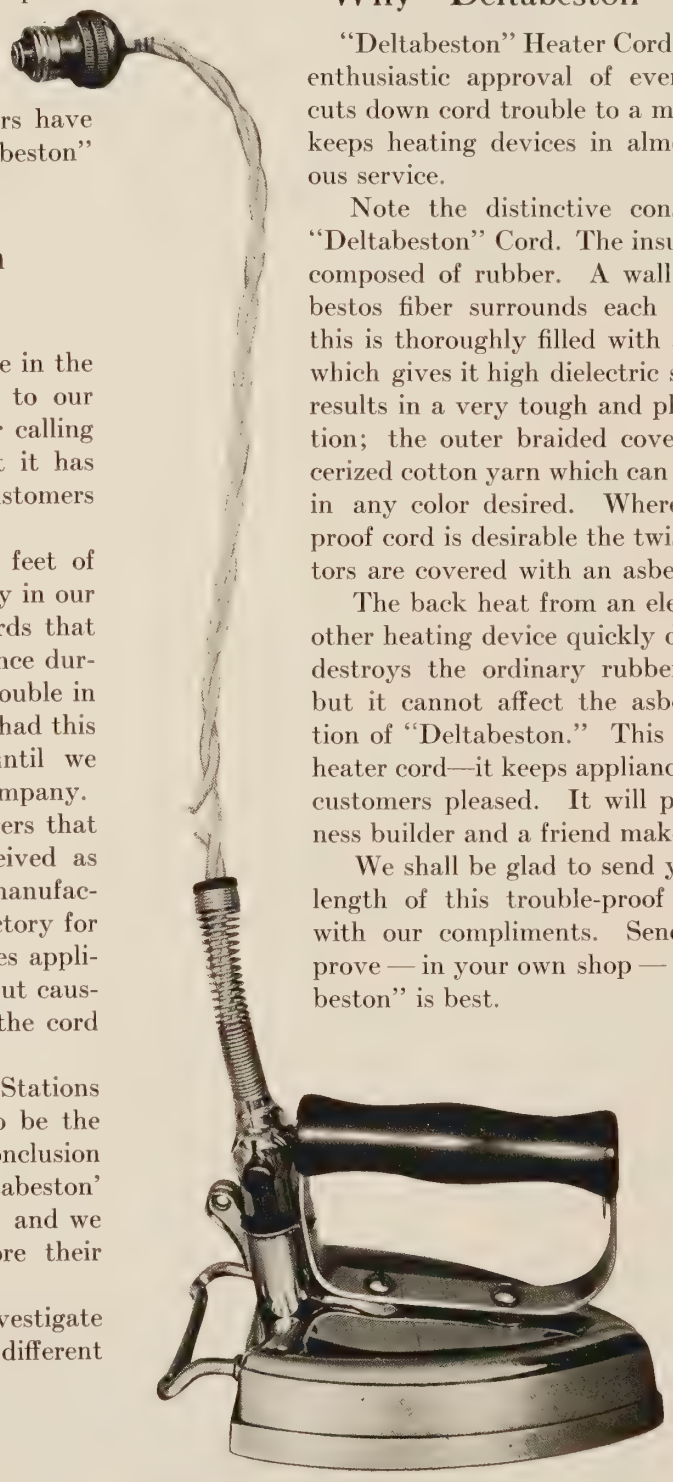
*"The Devices That Produce are the Devices in Use"*

### The Cord Without Rubber—Keeps the Iron in Constant Use

### A Business Builder and Friend Maker

A GOOD connecting cord means juice consumption. When the cord breaks there is a leak in your money bag — and a disgruntled customer.

Quite a number of Central Station managers have found the way to stop this leak with "Deltabeston" Heater Cord.



## What One Big Central Station Thinks About "Deltabeston"

"Our experience has shown a material decrease in the number of complaints from our customers due to our using this cord. We appreciate very much your calling our attention to this wire because we feel that it has saved us hundreds of dollars and given our customers better satisfaction.

"We are sending you our order for 10,000 feet of 'Deltabeston' Heater Cord. We use it exclusively in our appliance repair department to replace other cords that have become worn out. It has been our experience during the past several years that the majority of trouble in electrical appliances is with the cords. We have had this matter up with manufacturers continuously until we started to use the cord manufactured by your Company.

"We were informed by appliance manufacturers that there was no part of the appliance which received as thorough testing as the attaching cords. One manufacturer stated that they had a machine in their factory for testing the cords to ascertain the number of times appliances could be connected and disconnected without causing cord trouble and also to locate the spot in the cord where the trouble developed.

"On taking this matter up with other Central Stations we found their experience with cord troubles to be the same as our own, so that we have come to the conclusion that there is a tremendous field for the use of 'Deltabeston' Heater Cord, especially among Central Stations, and we would suggest that you bring the matter before their attention."

Surely there is every reason for you to investigate what "Deltabeston" Heater Cord is—why it is different —better—and how it will make money for you.

## Why "Deltabeston" Is Best

"Deltabeston" Heater Cord has won the enthusiastic approval of every user. It cuts down cord trouble to a minimum and keeps heating devices in almost continuous service.

Note the distinctive construction of "Deltabeston" Cord. The insulation is *not* composed of rubber. A wall of pure asbestos fiber surrounds each conductor—this is thoroughly filled with a compound which gives it high dielectric strength and results in a very tough and pliable insulation; the outer braided cover is of mercerized cotton yarn which can be furnished in any color desired. Where an all-fireproof cord is desirable the twisted conductors are covered with an asbestos braid.

The back heat from an electric iron or other heating device quickly dries out and destroys the ordinary rubber insulation, but it cannot affect the asbestos insulation of "Deltabeston." This is the ideal heater cord—it keeps appliances going and customers pleased. It will prove a business builder and a friend maker for you.

We shall be glad to send you a sample length of this trouble-proof heater cord with our compliments. Send for it and prove — in your own shop — that "Deltabeston" is best.

# WIRING TABLES
# PULLEYS AND GEARS
# STORAGE BATTERY DATA
# LAMP DATA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# WIRING TABLES

## BROWN & SHARPE'S GAUGE

The B. & S. gauge is standard for copper wire and is understood to apply in all cases where size of copper wire is mentioned in any wire gauge number.

By referring to the table it will be seen that in the B. & S. gauge, to all practical purposes, the area in circular mils is doubled for every third size heavier, by gauge number, and halved for every third size lighter, by gauge number.

Every tenth size heavier by gauge number has ten times the area in circular mils.

No. 10 B. & S. gauge wire has an area of approximately 10,000 circular mils, and from this base the other sizes can be figured, if a table should not be at hand.

## CLASSIFICATION OF GAUGES

In addition to the confusion caused by a multiplicity of wire gauges, several of them are known by various names.

For example:

Brown & Sharpe (B. & S.) = American Wire Gauge (A. W. G.).

New British Standard (N. B. S.) = British Imperial, English Legal Standard and Standard Wire Gauge and is variously abbreviated by S. W. G. and I. W. G.

Birmingham Gauge (B. W. G.) = Stubs' Old English Standard and Iron Wire Gauge.

Roebling = Washburn Moen, American Steel & Wire Co.'s Iron Wire Gauge.

London = Old English (Not Old English Standard).

As a further complication:

Birmingham or Stubs' Iron Wire Gauge is not the same as Stubs' Steel Wire Gauge.

## GENERAL USES OF VARIOUS GAUGES

B. & S. G.—All forms of round wires used for electrical conductors. Sheet Copper, Brass and German Silver.

U. S. S. G.—Sheet iron and steel. Legalized by act of Congress, March 3, 1893.

B. W. G.—Galvanized iron wire. Norway iron wire.

American Screw Co.'s Wire Gauge.—Numbered sizes of machine and wood screws, particularly up to No. 14 (.2421 inch).

Stubs' Steel Wire Gauge.—Drill rod.

Roebling & Trenton.—Iron and steel wire. Telephone and telegraph wire.

N. B. S.—Hard drawn copper. Telephone and telegraph wire.

London Gauge.—Brass wire.

## EQUIVALENTS OF WIRES: B. & S. GAUGE

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0000 | = | 2-0 | = | 4-3 | = | 8-6 | = | 16-9 | = | 32 12 | = | 64-15 |
| 000 | = | 2-1 | = | 4-4 | = | 8-7 | = | 16-10 | = | 32-13 | = | 64-16 |
| 00 | = | 2-2 | = | 4-5 | = | 8-8 | = | 16-11 | = | 32-14 | = | 64-17 |
| 0 | = | 2-3 | = | 4-6 | = | 8-9 | = | 16-12 | = | 32-15 | | .... |
| 1 | = | 2-4 | = | 4-7 | = | 8-10 | = | 16-13 | = | 32-16 | | ..... |
| 2 | = | 2-5 | = | 4-8 | = | 8-11 | = | 16-14 | = | 32-17 | | ..... |
| 3 | = | 2-6 | = | 4-9 | = | 8-12 | = | 16-15 | = | 32-18 | | ..... |
| 4 | = | 2-7 | = | 4-10 | = | 8-13 | = | 16-16 | | ..... | | ..... |
| 5 | = | 2-8 | = | 4-11 | = | 8-14 | = | 16-17 | | ..... | | ..... |
| 6 | = | 2-9 | = | 4-12 | = | 8-15 | = | 16-18 | | ..... | | ..... |
| 7 | = | 2-10 | = | 4-13 | = | 8 16 | | .... | | ..... | | ..... |
| 8 | = | 2-11 | = | 4-14 | = | 8-17 | | ..... | | ..... | | ..... |
| 9 | = | 2-12 | = | 4-15 | = | 8-18 | | ..... | | ..... | | ..... |
| 10 | = | 2-13 | = | 4-16 | | .... | | ..... | | ..... | | ..... |
| 11 | = | 2-14 | = | 4-17 | | .... | | ..... | | ..... | | ..... |
| 12 | = | 2-15 | = | 4-18 | | .... | | ..... | | ..... | | ..... |
| 13 | = | 2-16 | = | 4-19 | | .... | | ..... | | ..... | | ..... |
| 14 | = | 2-17 | | .... | | .... | | ..... | | ..... | | ..... |
| 15 | = | 2-18 | | .... | | .... | | ..... | | ..... | | ..... |
| 16 | = | 2-19 | | .... | | .... | | ..... | | ..... | | ..... |

## WEATHERPROOF WIRES—SOLID CONDUCTORS

| Size B. & S. | Weatherproof Wire Wgt. per 1000 Ft. | Weatherproof Wire Wgt. per Mile | Weatherproof Wire Diam. Over All | Slow-Burning Weatherproof Wire Wgt. per 1000 Ft. | Slow-Burning Weatherproof Wire Wgt. per Mile | Slow-Burning Weatherproof Wire Diam. Over All. | Slow-Burning Wire Wgt. per 1000 Ft. | Slow-Burning Wire Wgt. per Mile. | Slow-Burning Wire Diam. Over All. |
|---|---|---|---|---|---|---|---|---|---|
| 0000 | 767 | 4050 | 25/32 | 862 | 4550 | 3/4 | 925 | 4890 | 3/4 |
| 000 | 630 | 3220 | 47/64 | 710 | 3750 | 45/64 | 760 | 4020 | 45/64 |
| 00 | 502 | 2650 | 39/64 | 562 | 2970 | 37/64 | 600 | 3170 | 37/64 |
| 0 | 407 | 2150 | 9/16 | 462 | 2440 | 17/32 | 495 | 2610 | 17/32 |
| 1 | 316 | 1670 | 1/2 | 340 | 1800 | 15/32 | 365 | 1930 | 15/32 |
| 2 | 260 | 1370 | 15/32 | 280 | 1480 | 7/16 | 320 | 1690 | 7/16 |
| 3 | 200 | 1050 | 27/64 | 230 | 1220 | 13/32 | 270 | 1425 | 13/32 |
| 4 | 164 | 865 | 25/64 | 190 | 1000 | 3/8 | 220 | 1160 | 3/8 |
| 5 | 134 | 710 | 11/32 | 155 | 820 | 11/32 | 190 | 1000 | 11/32 |
| 6 | 112 | 590 | 5/16 | 127 | 670 | 5/16 | 160 | 845 | 5/16 |
| 8 | 75 | 395 | 17/64 | 85 | 450 | 7/64 | 100 | 530 | 17/64 |
| 10 | 53 | 280 | 1/4 | 60 | 315 | 1/4 | 80 | 420 | 1/4 |
| 12 | 35 | 185 | 7/32 | 42 | 220 | 7/32 | 55 | 290 | 7/32 |
| 14 | 25 | 130 | 3/16 | 30 | 160 | 3/16 | 40 | 210 | 3/16 |
| 16 | 14 | 75 | 5/32 | 15 | 80 | 5/32 | 18 | 95 | 5/32 |
| 18 | 11 | 58 | 1/8 | 12 | 63 | 1/8 | 14 | 75 | 1/8 |

## STRANDED CONDUCTORS

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000000 C.M. | 7000 | 37000 | 2 | 1/8 | 7300 | 38500 | 2 | | 7800 | 41000 | 2 | |
| 1750000 C.M. | 6200 | 32750 | 2 | | 6550 | 34600 | 1 | 7/8 | 6900 | 36300 | 1 | 7/8 |
| 1500000 C.M. | 5400 | 28500 | 1 | 7/8 | 5675 | 30000 | 1 | 3/4 | 6000 | 31300 | 1 | 3/4 |
| 1250000 C.M. | 4500 | 23800 | 1 | 3/4 | 4780 | 25200 | 1 | 11/16 | 5000 | 26400 | 1 | 11/16 |
| 1000000 C.M. | 3675 | 19400 | 1 | 21/32 | 3860 | 20400 | 1 | 39/64 | 3980 | 21000 | 1 | 39/64 |
| 900000 C.M. | 3330 | 17600 | 1 | 39/64 | 3520 | 18600 | 1 | 9/16 | 3640 | 19200 | 1 | 9/16 |
| 800000 C.M. | 3000 | 15800 | 1 | 9/16 | 3180 | 16800 | 1 | 33/64 | 3280 | 17300 | 1 | 33/64 |
| 700000 C.M. | 2650 | 14000 | 1 | 15/32 | 2820 | 14900 | 1 | 27/64 | 2920 | 15400 | 1 | 27/64 |
| 600000 C.M. | 2235 | 11800 | 1 | 21/64 | 2350 | 12400 | 1 | 9/32 | 2460 | 13000 | 1 | 9/32 |
| 500000 C.M. | 1900 | 10000 | 1 | 1/4 | 1990 | 10500 | 1 | 13/64 | 2080 | 11000 | 1 | 13/64 |
| 450000 C.M. | 1725 | 9100 | 1 | 3/16 | 1820 | 9600 | 1 | 9/64 | 1900 | 10000 | 1 | 9/64 |
| 400000 C.M. | 1550 | 8200 | 1 | 9/64 | 1650 | 8700 | 1 | 3/32 | 1700 | 9000 | 1 | 3/32 |
| 350000 C.M. | 1345 | 7100 | 1 | | 1440 | 7600 | 3 | 1/32 | 1500 | 7900 | | 31/32 |
| 300000 C.M. | 1175 | 6200 | | 31/32 | 1270 | 6700 | | 15/16 | 1310 | 6900 | | 15/16 |
| 250000 C.M. | 985 | 5200 | | 29/32 | 1060 | 5600 | | 7/8 | 1120 | 5900 | | 7/8 |
| 0000 | 800 | 4220 | | 55 64 | 900 | 4750 | | 53/64 | 940 | 5070 | | 53/64 |
| 000 | 653 | 3450 | | 51/64 | 735 | 3880 | | 49/64 | 785 | 4150 | | 49/64 |
| 00 | 522 | 2760 | | 43/64 | 583 | 3080 | | 41/64 | 625 | 3300 | | 41/64 |
| 0 | 424 | 2240 | | 39/64 | 480 | 2530 | | 37/64 | 510 | 2700 | | 37/64 |
| 1 | 328 | 1735 | | 35 64 | 355 | 1870 | | 33/64 | 380 | 2000 | | 33/64 |
| 2 | 270 | 1425 | | 33/64 | 290 | 1540 | | 31/64 | 335 | 1770 | | 31/64 |
| 3 | 206 | 1090 | | 15 32 | 240 | 1270 | | 29/64 | 280 | 1480 | | 29/64 |
| 4 | 170 | 900 | | 7/16 | 195 | 1030 | | 27/64 | 230 | 1220 | | 27/64 |
| 5 | 140 | 740 | | 3/8 | 160 | 845 | | 3/8 | 195 | 1030 | | 3/8 |
| 6 | 115 | 610 | | 11,32 | 132 | 695 | | 11/32 | 165 | 870 | | 11/32 |
| 8 | 78 | 410 | | 9/32 | 87 | 460 | | 9/32 | 105 | 555 | | 9/32 |

## ANNUNCIATOR WIRE

| Size B. & S. | Pounds per 1000 Ft. | Diameter Over All |
|---|---|---|
| 14 | 15. | ..... |
| 16 | 9.5 | ..... |
| 18 | 6.5 | ..... |
| 20 | 4.5 | ..... |

## DAMP-PROOF OFFICE WIRE

| Size B. & S. | Pounds per 1000 Ft. |
|---|---|
| 12 | 34. |
| 14 | 24. |
| 16 | 13.5 |
| 18 | 10. |
| 20 | 8. |

## FIXTURE WIRE—HEAVY WALL

| | | |
|---|---|---|
| 14 | 27 | 3/16 |
| 16 | 17 | 5/32 |
| 18 | 12 | 1/32 |
| 19 | 11 | 1/8 |
| 20 | 10 | 1/8 |

## TROLLEY WIRE

| | Pounds per Mile. |
|---|---|
| 0000 | 3376 |
| 000 | 2677 |
| 00 | 2123 |
| 0 | 1684 |

## LIGHT WALL

| | | |
|---|---|---|
| 16 | 12 | 1/8 |
| 18 | 9 | 7/64 |
| 19 | 8 | 7/64 |
| 20 | 7 | 3/32 |

## WEATHERPROOF TWISTED PAIRS

| | Per 1,000 Ft. |
|---|---|
| 14 | 53 |
| 16 | 32 |
| 18 | 23 |
| 19 | 20 |

## WEATHERPROOF IRON WIRE

| Size B. & S. | Pounds per Mile. |
|---|---|
| 8 | 470 |
| 9 | 400 |
| 10 | 350 |
| 12 | 230 |
| 14 | 150 |

All Weights are Approximate but are Exact Enough for all Practical Purposes.

## RUBBER COVERED WIRE—SOLID CONDUCTORS

| Size B. & S. | Diam. of Conductors Mils. | Capacity Circular Mils. | Single Braid Diam. Over All | Single Braid Weight Per 1,000 Ft. | Double Braid Diam. Over All | Double Braid Weight Per 1,000 Ft. |
|---|---|---|---|---|---|---|
| 0000 | 460 | 211600 | 47/64 | 809 | 55/64 | 832 |
| 000 | 410 | 167803 | 11/16 | 666 | 13/16 | 690 |
| 00 | 365 | 133079 | 5/8 | 546 | 47/64 | 568 |
| 0 | 325 | 105524 | 19/32 | 453 | 45/64 | 476 |
| 1 | 289 | 83695 | 33/64 | 355 | 5/8 | 376 |
| 2 | 258 | 66373 | 29/64 | 275 | 9/16 | 295 |
| 3 | 230 | 52634 | 27/64 | 227 | 33/64 | 245 |
| 4 | 204 | 41743 | 25/64 | 186 | 15/32 | 200 |
| 5 | 182 | 33102 | 23/64 | 160 | 7/16 | 170 |
| 6 | 162 | 26250 | 5/16 | 128 | 25/64 | 135 |
| 8 | 129 | 16510 | 17/64 | 80 | 11/32 | 86 |
| 10 | 102 | 10382 | 15/64 | 58 | 19/64 | 64 |
| 12 | 81 | 6530 | 7/32 | 43 | 9/32 | 48 |
| 14 | 64 | 4107 | 13/64 | 32 | 1/4 | 37 |
| 16 | 51 | 2583 | 3/16 | 20 | ..... | ... |
| 18 | 40 | 1624 | 11/64 | 16 | . . | ... |
| 19 | 36 | 1288 | 5/32 | 15 | ..... | ... |
| 20 | 32 | 1022 | 9/64 | 14 | ..... | ... |

## STRANDED CONDUCTORS

| Size B. & S. | Concentric No. Wires | Strands Diam. Each | Diam. of Conductors Mils. | Single Braid Diam. Over All | Single Braid Weight Per 1000 Ft. | Double Braid Diam. Over All | Double Braid Weight Per 1000 Ft. |
|---|---|---|---|---|---|---|---|
| 2000000 C.M. | 91 | 148 | 1650 | 2 | 7246 | 2 9/64 | 7385 |
| 1750000 C.M. | 91 | 139 | 1550 | 1 29/32 | 6394 | 2 3/64 | 6525 |
| 1500000 C.M. | 91 | 128 | 1430 | 1 51/64 | 5539 | 1 15/16 | 5658 |
| 1250000 C.M. | 91 | 117 | 1308 | 1 43/64 | 4678 | 1 13/16 | 4783 |
| 1000000 C.M. | 61 | 128 | 1166 | 1 1/2 | 3754 | 1 5/8 | 3849 |
| 900000 C.M. | 61 | 121 | 1104 | 1 7/16 | 3404 | 1 9/16 | 3491 |
| 800000 C.M. | 61 | 115 | 1049 | 1 3/8 | 3058 | 1 1/2 | 3138 |
| 750000 C.M. | 61 | 111 | 1013 | 1 11/32 | 2881 | 1 15/32 | 2956 |
| 700000 C.M. | 61 | 107 | 978 | 1 5/16 | 2709 | 1 7/16 | 2880 |
| 650000 C.M. | 61 | 103 | 943 | 1 17/64 | 2534 | 1 25/64 | 2600 |
| 600000 C.M. | 61 | 99 | 906 | 1 1/4 | 2355 | 1 3/8 | 2418 |
| 550000 C.M. | 61 | 95 | 870 | 1 13/64 | 2182 | 1 21/64 | 2240 |
| 500000 C.M. | 37 | 116 | 821 | 1 1/8 | 1959 | 1 1/4 | 2010 |
| 450000 C.M. | 37 | 110 | 779 | 1 3/32 | 1791 | 1 7/32 | 1840 |
| 400000 C.M. | 37 | 104 | 738 | 1 3/64 | 1608 | 1 11/64 | 1650 |
| 350000 C.M. | 37 | 97 | 688 | 1 | 1431 | 1 1/8 | 1468 |
| 300000 C.M. | 37 | 90 | 639 | 15/16 | 1250 | 1 1/16 | 1285 |
| 250000 C.M. | 37 | 82 | 583 | 7/8 | 1071 | 1 | 1103 |
| 0000 | 19 | .105 | 530 | 13/16 | 899 | 15/16 | 942 |
| 000 | 19 | .094 | 475 | 3/4 | 740 | 7/8 | 782 |
| 00 | 19 | .083 | 425 | 45/64 | 607 | 13/16 | 647 |
| 0 | 19 | .074 | 380 | 5/8 | 492 | 47/64 | 526 |
| 1 | 19 | .066 | 329 | 9/16 | 387 | 43/64 | 417 |
| 2 | 19 | .059 | 296 | 1/2 | 303 | 39/64 | 329 |
| 3 | 7 | .086 | 263 | 29/64 | 249 | 9/16 | 272 |
| 4 | 7 | .077 | 233 | 7/16 | 204 | 17/32 | 227 |
| 5 | 7 | .068 | 209 | 13/32 | 175 | 1/2 | 192 |
| 6 | 7 | .061 | 185 | 3/8 | 141 | 29/64 | 156 |
| 8 | 7 | .048 | 147 | 21/64 | 90 | 13/32 | 103 |
| 10 | 7 | .039 | 118 | 19/64 | 65 | 3/8 | 72 |
| 12 | 7 | .031 | 94 | 17/64 | 48 | 21/64 | 55 |
| 14 | 7 | .024 | 75 | 15/64 | 36 | 19/64 | 40 |

## RUBBER COVERED DUPLEX

| Size B. & S. | Solid Diameter Over All. | Solid Weight Per 1,000 Ft. | Stranded Diameter Over All. | Stranded Weight Per 1,000 Ft. |
|---|---|---|---|---|
| 1 | ..... | ... | 1 1/4 | 810 |
| 2 | ..... | ... | 1 1/8 | 638 |
| 3 | ..... | ... | 1 1/32 | 528 |
| 4 | ..... | ... | 31/32 | 442 |
| 5 | ..... | ... | 29/32 | 375 |
| 6 | ..... | ... | 53/64 | 307 |
| 8 | 11/16 | 170 | 49/64 | 203 |
| 10 | 37/64 | 125 | 5/8 | 143 |
| 12 | 1/2 | 94 | 9/16 | 107 |
| 14 | 27/64 | 73 | 15/32 | 78 |

All Weights are Approximate but are Exact Enough for all Practical Purposes

## GALVANIZED IRON WIRE—WEIGHT AND RESISTANCE CALCULATED AT 68° F.

| Iron Wire Gauge. | Diameter in Mils. | Pounds Per Mile. | Ohms Resistance Per Mile E. B. B. | B. B. | Steel. |
|---|---|---|---|---|---|
| 4 | .225 | 730 | 6.44 | 7.53 | 8.90 |
| 6 | .192 | 540 | 8.70 | 10.19 | 12.04 |
| 8 | .162 | 380 | 12.37 | 14.47 | 17.10 |
| 9 | .148 | 320 | 14.69 | 17.19 | 20.31 |
| 10 | .135 | 260 | 18.08 | 21.15 | 25.00 |
| 11 | .120 | 214 | 21.96 | 25.70 | 30.37 |
| 12 | .105 | 165 | 28.48 | 33.33 | 39.39 |
| 14 | .080 | 96 | 48.98 | 57.29 | 67.71 |

## DIMENSIONS, RESISTANCES AND SAFE CARRYING CAPACITY OF COPPER WIRES

| B. & S. Gauge No. | Diameter in Mils or Thousandths of an Inch | Area in Circular Mils | Ohms Per 1,000 Ft. | Lbs. Per 1,000 Ft. W. P. Ins. | Safe Amperes Rubber Covered | Safe Amperes Weather-proof |
|---|---|---|---|---|---|---|
| .... | 1,000 | 1,000,000 | .01038 | 3,550 | 650 | 1,000 |
| . . | 894 | 800,000 | .01297 | 2,880 | 550 | 840 |
| . . . | 775 | 600,000 | .0173 | 2,210 | 450 | 680 |
| .... | 707 | 500,000 | .02076 | 1,875 | 390 | 590 |
| . . . | 632 | 400,000 | .02596 | 1,530 | 330 | 500 |
| .... | 548 | 300,000 | .0346 | 1,185 | 270 | 400 |
| 0000 | 460 | 211,600 | .04906 | 750 | 210 | 312 |
| 000 | 410 | 167,805 | .06186 | 600 | 177 | 262 |
| 00 | 365 | 133,079 | .07801 | 500 | 150 | 220 |
| 0 | 325 | 105,592 | .0983 | 400 | 127 | 185 |
| 1 | 289 | 83,694 | .1240 | 300 | 107 | 156 |
| 2 | 258 | 66,373 | .1564 | 250 | 90 | 131 |
| 3 | 229 | 52,633 | .1972 | 200 | 76 | 110 |
| 4 | 204 | 41,742 | .2487 | 160 | 65 | 92 |
| 5 | 182 | 33,102 | .3136 | 140 | 54 | 77 |
| 6 | 162 | 26,250 | .3955 | 110 | 46 | 65 |
| 8 | 128 | 16,509 | .6288 | 75 | 33 | 46 |
| 10 | 102 | 10,381 | 1. | 50 | 24 | 32 |
| 12 | 81 | 6,530 | 1.590 | 35 | 17 | 23 |
| 14 | .. | 4,107 | 2.591 | 25 | 12 | 16 |
| 16 | 51 | 2,583 | 4.019 | 16 | 6 | 8 |
| 18 | 40 | 1,624 | 6.391 | 12 | 3 | 5 |

## TO DETERMINE THE SIZE OF COPPER WIRE FOR ANY GIVEN SERVICE

Let C. M. = Cir. Mils.
Let D. = Distance.
Let C. = Current.
Let L. = Loss in Volts.

21.5 is a "Constant" or figure always used.

$$\text{Then } \frac{\text{C.} \times \text{D.} \times 21.5}{\text{L.}} = \text{Cir. Mils.}$$

Example.—It is required that 100 amperes be carried 350 feet on a 110 volt circuit, with a loss of 2 per cent. in voltage. What is the Cir. Mils required?

Example.—First, ascertain the loss in volts, or 2 per cent. of 110 = 2.2 volts.

$$\frac{100 \times 350 \times 21.5}{2.2} = 337.500 \text{ Cir. Mils. or two—No. 000 Wires.}$$

Where a wiring table is not at hand and it is desired to ascertain the weight of any bare copper conductor, it can be roughly determined in accordance with the following:

1000 feet of wire having an area of 1000 circular mils weighs approximately three pounds, and the weight of any bare conductor can, therefore, be determined by multiplying its area in circular mils by .003.

## CURRENT REQUIRED TO FUSE WIRES OF COPPER, GERMAN SILVER AND IRON

| B. & S. Gauge. | Copper Amperes. | German Silver Amperes. | Iron Amperes. | B.& S. Gauge. | Copper Amperes. | German Silver, Amperes. | Iron Amperes. |
|---|---|---|---|---|---|---|---|
| 10 | 333. | 169. | 101. | 26 | 20.6 | 10.6 | 6.22 |
| 11 | 284. | 146. | 86. | 27 | 17.7 | 9.1 | 5.36 |
| 12 | 235. | 120.7 | 71.2 | 28 | 14.7 | 7.5 | 4.45 |
| 13 | 200. | 102.6 | 63. | 29 | 12.5 | 6.41 | 3.79 |
| 14 | 166. | 85.2 | 50.2 | 30 | 10.25 | 5.26 | 3.11 |
| 15 | 139. | 71.2 | 42.1 | 31 | 8.75 | 4.49 | 2.65 |
| 16 | 117. | 60. | 35.5 | 32 | 7.26 | 3.73 | 2.2 |
| 17 | 99. | 50.4 | 32.6 | 33 | 6.19 | 3.18 | 1.88 |
| 18 | 82.8 | 42.5 | 25.1 | 34 | 5.12 | 2.64 | 1.55 |
| 19 | 66.7 | 34.2 | 20.2 | 35 | 4.37 | 2.24 | 1.33 |
| 20 | 58.3 | 29.9 | 17.7 | 36 | 3.62 | 1.86 | 1.09 |
| 21 | 49.3 | 25.3 | 14.9 | 37 | 3.08 | 1.58 | .93 |
| 22 | 41.2 | 21.1 | 12.5 | 38 | 2.55 | 1.31 | .77 |
| 23 | 34.5 | 17.7 | 10.9 | 39 | 2.20 | 1.13 | .67 |
| 24 | 28.9 | 14.8 | 8.76 | 40 | 1.86 | .95 | .56 |
| 25 | 24.6 | 12.6 | 7.46 | | | | |

## ELECTRICAL UNITS

The electrical units are derived from the following mechanical units of the metric system:

*Centimeter.* Unit of Length—One thousand millionth part of a quadrant of the earth's surface.

*Gramme.* Unit of Weight—Weight of a cubic centimeter of water at a temperature of 4 degrees centigrade.

*Second.* Unit of Time—The time of one swing of a pendulum making 86,400 swings in a solar day.

The unit of area is the square centimeter. The unit of volume is the cubic centimeter.

*Volt*—Unit of electro-motive force; pressure of potential. Symbol E.

*Ohm*—Unit of resistance. Symbol R.

*Megohm*—1,000,000 ohms.

*Ampere*—Unit of current. Symbol C.

*Ampere hours*—Current in amperes × time in hours.

*Watt*—Unit of power. Product of 1 volt × 1 ampere. Symbol W. or E. C. (746) watts equal one horse power.

*Horse Power*—746 watts.

*Kilowatt*—1000 watts. Written K. W.

*Kilowatt Hours*—Kilowatts × time in hours.

*Farad*—Unit of capacity.

*Microfarad*—One-millionth of a farad. Written M. F.

*Coulomb.* Unit of Quantity—Quantity of current which, impelled by one volt, would pass through one ohm in one second.

*Joule.* Unit of Work—The work done by one watt in one second.

## MILS AND CIRCULAR MILS

The one-thousandth part of one inch, written .001, and usually called one mil, is taken as the unit of diameter, from which one square mil would be the unit of area. If you measure the diameter of a round wire in thousandths of an inch, or mils, by means of a micrometer, and multiply this number by itself, i.e., square it, you obtain in square mils the cross-sectional area of a square wire having four sides, each the same length as the diameter of the round wire that you have calipered.

Circular mil (usually written C. M.) applies to all round wires, and has a value .785 times that of the square mil.

Consequently the square of the diameter of any round wire, measured in mils, gives its cross-sectional area in circular mils, without any further multiplication.

Conversely, if you extract the square root of the number of circular mils by which a round wire is listed, you obtain its diameter in mils.

Let d = diameter of a wire in mils.
n = the number of wires.

C.M. = the area of the conductor in cir. mils.

Then $C.M. = d^2n$

$$n = \frac{C.M.}{d^2} \qquad d = \frac{\sqrt{C.M.}}{n}$$

A mil is 1-1000 of an inch.

The diameter of a circle expressed in mils and squared gives its area in circular mils. Expressed in millimeters and squared gives its area in circular millimeters.

A Wire Rod, commonly called a Rod, is formed by hot rolling from the copper billet and is usually made into wire by cold drawing thru dies.

A Right Lay Strand is one in which the wires go in the same way as the threads of a right-hand screw. A Left Lay Strand is the opposite.

A Perfect Strand is made by twisting around one wire as a center, six wires, around this twelve wires, eighteen, twenty-four, and so on.

A Lay of a Strand is the length of the helix, measured parallel to the axis of the strand, which each wire forms around the center of the strand.

## WEIGHT OF COPPER

A convenient formula for weight of copper is as follows:

$$\text{Lbs. copper in line} = \frac{(\text{miles})^2 \times \text{K.W.} \times k}{(\text{K.V.})^2 \times \% \text{ loss}}$$

k = a constant depending on phase, system and power factor; for 100% power factor, single or two-phase, k = 363; for three-phase, K = 273.

## OHM'S LAW

The Electrical Units—volt, ohm and ampere, which are most frequently used, have fortunately been established so as to bear simple but important relations to one another, based upon the current increasing and decreasing with the voltage, but increasing when the resistance decreases, and decreasing when the resistance increases.

Using the Symbols mentioned above, this is expressed in the following equations:

$$C = \frac{E}{R} \qquad E = C.\,R. \qquad R = \frac{E}{C} \qquad E.\,C.\ (\text{or watts}) = C^2R.$$

$$E.\,C.\ (\text{or watts}) = \frac{E^2}{R}$$

## TABLE SHOWING DIFFERENCE BETWEEN WIRE GAUGES IN DECIMAL PARTS OF AN INCH

| No. of Wire Gauge | American or Brown & Sharpe | Birmingham or Stubs | Washburn & Moen Mfg. Co., Worcester, Mass. | Trenton Iron Co., Trenton, N. J. | New British | Old English from Brass Mfrs. List | No. of Wire |
|---|---|---|---|---|---|---|---|
| 000000 | ..... | .... | .46 | ..... | .... | .... | 000000 |
| 00000 | ..... | .... | .43 | .45 | .... | .... | 00000 |
| 0000 | .46 | .454 | .393 | .4 | .4 | .... | 0000 |
| 000 | .40964 | .425 | .362 | .36 | .372 | .... | 000 |
| 00 | .3648 | .38 | .331 | .33 | .348 | .... | 00 |
| 0 | .32495 | .34 | .307 | .305 | .324 | .... | 0 |
| 1 | .2893 | .3 | .283 | .285 | .3 | .... | 1 |
| 2 | 25763 | .284 | .263 | .265 | .276 | .... | 2 |
| 3 | 22942 | .259 | .244 | .245 | .252 | .... | 3 |
| 4 | .20431 | .238 | .225 | .225 | .232 | .... | 4 |
| 5 | .18194 | .22 | .207 | .205 | .212 | .... | 5 |
| 6 | .16202 | .203 | .192 | .19 | .192 | .... | 6 |
| 7 | .14428 | .18 | .177 | .175 | .176 | .... | 7 |
| 8 | .12849 | .165 | .162 | .16 | .16 | .... | 8 |
| 9 | .11443 | .148 | .148 | .145 | .144 | .... | 9 |
| 10 | .10189 | .134 | .135 | .13 | .128 | .... | 10 |
| 11 | .090742 | .12 | .12 | .1175 | .116 | .... | 11 |
| 12 | .080808 | .109 | .105 | .105 | .104 | .... | 12 |
| 13 | .071961 | .095 | .092 | .0925 | .092 | .... | 13 |
| 14 | .064084 | .083 | .08 | .08 | .08 | .083 | 14 |
| 15 | .057068 | .072 | .072 | .07 | .072 | .072 | 15 |
| 16 | .05082 | .065 | .063 | .061 | .064 | .065 | 16 |
| 17 | .045257 | .058 | .054 | .0525 | .056 | .058 | 17 |
| 18 | .040303 | .049 | .047 | .045 | .048 | .049 | 18 |
| 19 | .03589 | .042 | .041 | .039 | .04 | .04 | 19 |
| 20 | .031961 | .035 | .035 | .034 | .036 | .035 | 20 |
| 21 | .028462 | .032 | .032 | .03 | .032 | .0315 | 21 |
| 22 | .025347 | .028 | .028 | .27 | .028 | .0295 | 22 |
| 23 | .022571 | .025 | .025 | .024 | .024 | .027 | 23 |
| 24 | .0201 | .022 | .023 | .0215 | .022 | .025 | 24 |
| 25 | .0179 | .02 | .02 | .019 | .02 | .023 | 25 |
| 26 | .01594 | .018 | .018 | .018 | .018 | .0205 | 26 |
| 27 | .014195 | .016 | .017 | .017 | .0164 | .01875 | 27 |
| 28 | .012641 | .014 | .016 | .016 | .0148 | .0165 | 28 |
| 29 | .011257 | .013 | .015 | .015 | .0136 | .0155 | 29 |
| 30 | .010025 | .012 | .014 | .014 | .0124 | .01375 | 30 |
| 31 | .008928 | .01 | .0135 | .013 | .0116 | 01225 | 31 |
| 32 | .00795 | .009 | .013 | .012 | .0108 | .01125 | 32 |
| 33 | .00708 | .008 | .011 | .011 | .01 | .01025 | 33 |
| 34 | .006304 | .007 | .01 | .01 | .0092 | .0095 | 34 |
| 35 | .005614 | .005 | .0095 | .009 | .0084 | .009 | 35 |
| 36 | .005 | .004 | .009 | .008 | .0076 | .0075 | 36 |
| 37 | .004453 | .... | .0085 | .00725 | .0068 | .0065 | 37 |
| 38 | .003965 | .... | .008 | .0065 | .006 | .00575 | 38 |
| 39 | .003531 | .... | .0075 | .00575 | .0052 | .005 | 39 |
| 40 | .003144 | .... | .007 | .005 | .0048 | .0045 | 40 |

## COPPER FOR VARIOUS SYSTEMS OF DISTRIBUTION

Power transmitted, distance, line loss and voltage of lamps constant. All wires of each system, same size.

| System. | Copper Required. |
|---|---|
| 2-Wire, single-phase or direct current | 1.000 |
| 3-Wire, single-phase or direct current | .375 |
| 4-Wire, single-phase or direct current | .222 |
| 4-Wire, two-phase | 1.000 |
| 4-Wire, three-phase with neutral | .333 |
| 3-Wire, three-phase Delta | .75 |

## SAFE CARRYING CAPACITY OF INSULATED WIRES

As given by National Board of Fire Underwriters

| Size B. & S. | Circular Mils | Carrying Capacity in Amperes | |
|---|---|---|---|
| | | Rubber Covered | Weatherproof |
| | 1000000 | 650 | 1000 |
| | 900000 | 600 | 920 |
| | 800000 | 550 | 840 |
| | 700000 | 500 | 760 |
| | 600000 | 450 | 680 |
| | 500000 | 400 | 600 |
| | 450000 | 370 | 550 |
| | 400000 | 325 | 500 |
| | 350000 | 300 | 450 |
| | 300000 | 275 | 400 |
| | 250000 | 240 | 350 |
| 0000 | 211600.00 | 225 | 325 |
| 000 | 167772.16 | 175 | 275 |
| 00 | 133079.04 | 150 | 225 |
| 0 | 105560.01 | 125 | 200 |
| 1 | 83694.49 | 100 | 150 |
| 2 | 66357.76 | 90 | 125 |
| 3 | 52624.36 | 80 | 100 |
| 4 | 41738.49 | 70 | 90 |
| 5 | 33087.61 | 55 | 80 |
| 6 | 26244.00 | 50 | 70 |
| 8 | 16512.25 | 35 | 50 |
| 10 | 10383.61 | 25 | 30 |
| 12 | 6528.64 | 20 | 25 |
| 14 | 4108.81 | 15 | 20 |
| 16 | 2580.64 | 6 | 10 |
| 18 | 1624.09 | 3 | 5 |

The lower limit is specified for rubber-covered wires to prevent gradual deterioration of the rubber from the heat of the wire. The question of drop is not taken into consideration in the table.

## FINE MAGNET WIRE

| No. B. & S. Gauge. | Diameter | Ohms, Per Pound | | Feet, Per Pound | |
|---|---|---|---|---|---|
| | | Single Cotton | Double Cotton | Single Cotton | Double Cotton |
| 20 | .0319 | 3.15 | 3.02 | 311 | 298 |
| 21 | .0284 | 4.97 | 4.72 | 389 | 370 |
| 22 | .0253 | 7.87 | 7.44 | 491 | 461 |
| 23 | .0225 | 12.45 | 11.7 | 624 | 584 |
| 24 | .0201 | 19.65 | 18.25 | 778 | 745 |
| 25 | .0179 | 30.9 | 28.45 | 958 | 903 |
| 26 | .0159 | 48.5 | 44.3 | 1188 | 1118 |
| 27 | .0142 | 76.5 | 68.8 | 1533 | 1422 |
| 28 | .0126 | 120. | 106.5 | 1903 | 1759 |
| 29 | .0112 | 190.5 | 164. | 2461 | 2207 |
| 30 | .0100 | 294.5 | 252. | 2893 | 2534 |
| 31 | .0089 | 461. | 384.5 | 3483 | 2768 |
| 32 | .0079 | 717. | 585. | 4414 | 3737 |
| 33 | .0070 | 1115. | 880. | 5688 | 4697 |
| 34 | .0063 | 1715. | 1315. | 6400 | 6168 |
| 35 | .0056 | 2640. | 1960. | 8393 | 6737 |
| 36 | .005 | 4070. | 2890. | 9846 | 7877 |
| 37 | .0044 | 6180. | 4230. | 11636 | 9309 |
| 38 | .0039 | 9430. | 6150. | 13848 | 10666 |
| 39 | .0035 | 14200. | 8850. | 18286 | 11907 |
| 40 | .0031 | 21300. | 12500. | 24381 | 14222 |

## DATA ON SOLID WIRES LARGER THAN 4/0

| No. B. & S. Gauge. | Dia. Mils. | Circular Mils. | Feet Per Pound | Pounds Per Foot | Ohms, Per Mile |
|---|---|---|---|---|---|
| 5/0 | 515 | 265,225 | 1.29 | .80 | .206 |
| 6/0 | 575 | 330,625 | 1.00 | 1.00 | .165 |
| 7/0 | 640 | 409,600 | .81 | 1.24 | .133 |
| 8/0 | 710 | 504,100 | .66 | 1.53 | .108 |
| 9/0 | 785 | 616,225 | .54 | 1.86 | .089 |
| 10/0 | 865 | 748,225 | .44 | 2.25 | .073 |
| 11/0 | 950 | 902,500 | .37 | 2.73 | .060 |
| 12/0 | 1040 | 1,081,600 | .21 | 3.27 | .050 |

## ELECTRICAL UNITS AND MECHANICAL EQUIVALENTS

### Alternating Current

| At Voltage of | 1000 | 2000 | 3000 | 4000 | 5000 | |
|---|---|---|---|---|---|---|
| 1 Horse Power = | 3/5 | 3/10 | 1/5 | 3/20 | 1/8 | Ampere |
| 1 Ampere = | 2/3 | 3 1/3 | 5 | 6 2/3 | 8 1/3 | Horse Power |

### Amperes Per Horse Power

The following table shows number of amperes required per horse power when the percentage of efficiency of the motor is known.

| Efficiency of Motor. | 75 Per Cent. | 80 Per Cent. | 85 Per Cent. | 90 Per Cent. |
|---|---|---|---|---|
| At 110 Volts. | 9 Amp. | 8.4 Amp. | 7.9 Amp. | 7.5 Amp. |
| At 220 Volts. | 4.5 Amp. | 4.2 Amp. | 3.95 Amp. | 3.75 Amp. |
| At 500 Volts. | 1.98 Amp. | 1.86 Amp. | 1.75 Amp. | 1.66 Amp. |

### Amperes Per Generator

| K.W. | 125 Vs. | 250 Vs. | 500 Vs. | Appx. H.P. | K.W. | 125 Vs. | 250 Vs. | 500 Vs. | Appx. H.P. |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 8 | 4 | 2 | 1.3 | 30. | 240 | 120 | 60 | 40 |
| 2. | 16 | 8 | 4 | 2.7 | 37.5 | 300 | 150 | 75 | 50 |
| 3. | 24 | 12 | 6 | 4.0 | 40. | 320 | 160 | 80 | 53 |
| 5. | 40 | 20 | 10 | 6.7 | 50. | 400 | 200 | 100 | 67 |
| 7.5 | 60 | 30 | 15 | 10. | 60. | 480 | 240 | 120 | 80 |
| 10. | 80 | 40 | 20 | 13. | 75. | 600 | 300 | 150 | 100 |
| 12.5 | 100 | 50 | 25 | 17. | 100. | 800 | 400 | 200 | 134 |
| 15. | 120 | 60 | 30 | 20. | 125. | 1000 | 500 | 250 | 167 |
| 20. | 160 | 80 | 40 | 27. | 150. | 1200 | 600 | 300 | 201 |
| 25. | 200 | 100 | 50 | 34. | 200. | 1600 | 800 | 400 | 268 |

### Amperes Per Motor

| H. P. | Per Cent. Eff. | Watts Input. | 50 Volts. | 100 Volts. | 220 Volts. | 500 Volts. |
|---|---|---|---|---|---|---|
| ¾ | 70 | 800 | 16 | 7 | 4 | 2 |
| 1½ | 70 | 1600 | 32 | 15 | 7 | 3 |
| 3 | 75 | 2980 | 60 | 27 | 14 | 6 |
| 5 | 80 | 4660 | 93 | 42 | 21 | 9 |
| 7½ | 85 | 6580 | 132 | 60 | 30 | 13 |
| 10 | 85 | 8780 | 176 | 80 | 40 | 18 |
| 15 | 85 | 13200 | 264 | 120 | 60 | 26 |
| 20 | 85 | 17600 | 352 | 160 | 80 | 35 |
| 25 | 85 | 21900 | 438 | 199 | 100 | 44 |
| 30 | 90 | 24900 | 498 | 226 | 113 | 50 |
| 40 | 90 | 33200 | 664 | 301 | 151 | 66 |
| 50 | 90 | 41400 | 828 | 376 | 188 | 83 |
| 60 | 90 | 49700 | 994 | 452 | 226 | 99 |
| 70 | 90 | 58000 | 1160 | 527 | 264 | 116 |
| 80 | 90 | 66300 | 1330 | 603 | 302 | 133 |
| 90 | 90 | 74600 | 1490 | 678 | 339 | 149 |
| 100 | 90 | 82900 | 1660 | 755 | 377 | 166 |
| 120 | 90 | 99500 | 1990 | 905 | 453 | 199 |
| 150 | 90 | 124000 | 2480 | 1130 | 564 | 248 |

C = Current in Amperes.
HP = Horse Power.
E = Voltage.
K = Efficiency of Motor.

$$C = \frac{HP \times 74600}{E \times K}$$

## CONDUCTIVITIES

| Metals | At 0° C. At 32° F. | At 100° C. At 212° F. |
|---|---|---|
| Silver, hard | 100. | 71.56 |
| Copper, hard | 99.95 | 70.27 |
| Gold, hard | 77.96 | 55.90 |
| Zinc, pressed | 29.02 | 20.67 |
| Cadmium | 23.72 | 16.77 |
| Platinum, soft | 18.00 | |
| Iron, soft | 16.80 | |
| Tin | 12.36 | 8.67 |
| Lead | 8.32 | 5.86 |
| Arsenic | 4.76 | 3.33 |
| Antimony | 4.62 | 3.26 |
| Mercury, pure | 1.60 | |
| Bismuth | 1.245 | 0.878 |

## COMPARISON OF WIRE GAUGES

| Size | Brown and Sharpe | Birmingham or Stubs | New British or English Legal | Iron Wire |
|---|---|---|---|---|
| 0000 | .460 0000 | .454 | .400 | .394 |
| 000 | .409 6431 | .425 | .372 | .363 |
| 00 | .364 7977 | .380 | .348 | .331 |
| 0 | .324 8617 | .340 | .324 | .307 |
| 1 | .289 2977 | .300 | .300 | .283 |
| 2 | .257 6270 | .284 | .276 | .263 |
| 3 | .229 4235 | .259 | .252 | .244 |
| 4 | .204 3075 | .238 | .232 | .225 |
| 5 | .181 9411 | .220 | .212 | .207 |
| 6 | .162 0232 | .203 | .192 | .192 |
| 7 | .144 2858 | .180 | .176 | .177 |
| 8 | .128 4902 | .165 | .160 | .162 |
| 9 | .114 4238 | .148 | .144 | .148 |
| 10 | .101 8973 | .134 | .128 | .135 |
| 11 | .090 7432 | .120 | .116 | .121 |
| 12 | .080 8083 | .109 | .104 | .106 |
| 13 | .071 9619 | .095 | .092 | .092 |
| 14 | .064 0839 | .083 | .080 | .080 |
| 15 | .057 0684 | .072 | .072 | .072 |
| 16 | .050 8209 | .065 | .064 | .063 |
| 17 | .045 2573 | .058 | .059 | .054 |
| 18 | .040 3028 | .049 | .048 | .048 |
| 19 | .035 8907 | .042 | .040 | .041 |
| 20 | .031 9616 | .035 | .036 | .035 |
| 21 | .028 4626 | .032 | .032 | .032 |
| 22 | .025 3467 | .028 | .028 | .029 |
| 23 | .022 5719 | .025 | .024 | .026 |
| 24 | .020 1009 | .022 | .022 | .023 |
| 25 | .017 9004 | .020 | .020 | .020 |
| 26 | .015 9408 | .018 | .018 | .018 |
| 27 | .014 1957 | .016 | .016 4 | .017 |
| 28 | .012 6416 | .014 | .014 8 | .016 |
| 29 | .011 2577 | .013 | .013 6 | .015 |
| 30 | .010 0253 | .012 | .012 4 | .014 |
| 31 | .008 9278 | .010 | .011 6 | .013 2 |
| 32 | .007 9504 | .009 | .010 8 | .012 8 |
| 33 | .007 0800 | .008 | .010 0 | .011 8 |
| 34 | .006 3049 | .007 | .009 2 | .010 4 |
| 35 | .005 6147 | .005 | .008 4 | .009 5 |
| 36 | .005 0000 | .004 | .007 6 | .009 0 |

## COMPARATIVE WEIGHTS OF WIRES

| Size B. & S. Gauge | Weight in Pounds per 1000 Feet | | | |
|---|---|---|---|---|
| | Copper | Aluminum | Iron or Steel | Brass |
| 0000 | 640.5 | 194.5 | 558.4 | 605.18 |
| 000 | 507.8 | 154.3 | 442.8 | 479.91 |
| 00 | 402.8 | 122.3 | 351.2 | 380.67 |
| 0 | 319.5 | 97.04 | 278.5 | 301.82 |
| 1 | 253.3 | 76.93 | 220.9 | 239.35 |
| 2 | 200.9 | 61.02 | 175.1 | 189.82 |
| 3 | 159.3 | 48.38 | 149.5 | 150.52 |
| 4 | 126.3 | 38.39 | 110.2 | 119.38 |
| 5 | 100.2 | 30.43 | 87.40 | 94.666 |
| 6 | 79.44 | 24.13 | 70.00 | 75.075 |
| 7 | 63.03 | 19.14 | 55.54 | 59.545 |
| 8 | 49.98 | 15.18 | 44.04 | 47.219 |
| 9 | 39.61 | 12.04 | 34.91 | 37.437 |
| 10 | 31.43 | 9.546 | 27.70 | 29.687 |
| 11 | 24.90 | 7.569 | 21.94 | 23.549 |
| 12 | 19.76 | 6.004 | 17.41 | 18.676 |
| 13 | 15.69 | 4.762 | 13.83 | 14.809 |
| 14 | 12.44 | 3.775 | 10.96 | 11.746 |
| 15 | 9.869 | 2.994 | 8.696 | 9.315 |
| 16 | 7.812 | 2.374 | 6.883 | 7.587 |
| 17 | 6.212 | 1.883 | 5.473 | 5.857 |
| 18 | 4.916 | 1.493 | 4.332 | 4.645 |
| 19 | 3.901 | 1.184 | 3.438 | 3.684 |
| 20 | 3.100 | .939 1 | 2.731 | 2.920 |
| 21 | 2.459 | .744 7 | 2.166 | 2.317 |
| 22 | 1.938 | .590 7 | 1.707 | 1.838 |
| 23 | 1.546 | .468 3 | 1.362 | 1.457 |
| 24 | 1.223 | .371 4 | 1.078 | 1.155 |
| 25 | .969 9 | .294 6 | .854 6 | .916 3 |
| 26 | .765 2 | .233 6 | .674 3 | .726 7 |
| 27 | .610 4 | .185 3 | .537 8 | .576 3 |
| 28 | .480 6 | .146 9 | .423 4 | .457 0 |
| 29 | .386 5 | .116 5 | .340 6 | .362 4 |
| 30 | .302 7 | .092 4 | .266 7 | .287 4 |
| 31 | .239 8 | .073 3 | .212 7 | .228 0 |
| 32 | .193 7 | .058 1 | .168 6 | .180 8 |
| 33 | .152 6 | .046 1 | .133 7 | .143 4 |
| 34 | .120 1 | .036 5 | .105 9 | .113 7 |
| 35 | .094 9 | .029 0 | .083 9 | .090 1 |
| 36 | .075 7 | .023 0 | .066 6 | .071 5 |

## POLE LINE DATA

Showing the distance between poles according to the number of poles used per mile.

## WIRES ON POLE LINES

Also the weight of wire in the suspension between poles, allowing for sag, calculated on weights of "O. K." triple-braided line wires.

| Number of poles per mile | | | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Distance between poles in ft. | | | 176′ | 151′ | 132′ | 117′ | 105′ | 96′ | 88′ | 81′ | 75′ | 70′ |
| B. & S. Gauge Solid | C. M. Capacity Stranded | Weight Lbs. Per Mile | WEIGHT IN POUNDS OF WIRE IN SPAN | | | | | | | | | |
| | 1000000 | 19400 | 655 | 562 | 491 | 435 | 390 | 356 | 326 | 300 | 277 | 258 |
| | 900000 | 17600 | 597 | 511 | 446 | 393 | 355 | 324 | 295 | 272 | 241 | 235 |
| | 800000 | 15800 | 536 | 459 | 400 | 355 | 318 | 290 | 266 | 244 | 226 | 211 |
| | 700000 | 14000 | 473 | 405 | 354 | 313 | 280 | 256 | 234 | 215 | 200 | 186 |
| | 600000 | 11800 | 405 | 347 | 303 | 268 | 240 | 219 | 201 | 184 | 171 | 159 |
| | 500000 | 10000 | 340 | 281 | 253 | 224 | 200 | 183 | 168 | 154 | 143 | 133 |
| | 450000 | 9100 | 314 | 269 | 235 | 208 | 186 | 170 | 156 | 140 | 132 | 123 |
| | 400000 | 8200 | 284 | 243 | 212 | 188 | 168 | 153 | 140 | 129 | 120 | 111 |
| | 350000 | 7100 | 239 | 204 | 178 | 158 | 141 | 129 | 118 | 109 | 101 | 94 |
| | 300000 | 6200 | 209 | 179 | 156 | 138 | 124 | 113 | 103 | 95 | 88 | 82 |
| | 250000 | 5200 | 175 | 150 | 130 | 115 | 103 | 94 | 86 | 79 | 74 | 69 |
| 0000 | | 4050 | 136 | 117 | 102 | 89 | 81 | 74 | 68 | 62 | 58 | |
| 000 | | 3320 | 112 | 96 | 84 | 74 | 67 | 61 | 56 | 51 | 47 | |
| 00 | | 2650 | 89 | 77 | 67 | 59 | 53 | 48 | 44 | 41 | | |
| 0 | | 2150 | 72 | 62 | 54 | 48 | 43 | 39 | 36 | 33 | | |
| 1 | | 1670 | 56 | 48 | 42 | 37 | 33 | 30 | 28 | | | |
| 2 | | 1370 | 46 | 40 | 35 | 31 | 27 | 25 | 23 | | | |
| 3 | | 1050 | 36 | 31 | 27 | 24 | 21 | 19 | | | | |
| 4 | | 865 | 29 | 25 | 22 | 19 | 17 | 16 | | | | |
| 5 | | 710 | 24 | 20 | 18 | 16 | 14 | | | | | |
| 6 | | 590 | 20 | 17 | 15 | 13 | 12 | | | | | |
| 8 | | 395 | 13 | 11 | 10 | 9 | | | | | | |
| 10 | | 280 | 9 | 8 | 7 | 6 | | | | | | |

## WIRING FORMULA FOR DIRECT CURRENT

D = distance (one way) in feet.

C = current in amperes.

CM = circular mils.

$$\text{Volts lost} = \frac{D \times 22 \times C}{CM}$$

$$CM = \frac{D \times 22 \times C}{\text{volts lost}}$$

The constant 22 is obtained as follows: A copper wire with a sectional area of 10.7 CM, has a resistance of one ohm per foot. One ampere through one ohm resistance loses one volt.

The distance being measured one way, we multiply by 2 to get the total length of the circuit. As $10.7 \times 2 = 21.4$ we may use 22 for simplicity, this being near enough for practical work.

## WIRING FORMULA

From Ohm's Law the proper size of wire that should be used to carry a current any distance with a given loss in volts can readily be determined, and the following is recommended:

$$\frac{\text{Length of run in feet} \times \text{amperes} \times 21.5}{\text{Volts lost}} = \text{Circular Mils.}$$

In above the number of feet must be measured one way, not both sides of the circuit; volts lost should be taken as the drop allowed in volts, and circular mils show the size of wire to use.

Example.—What size wire should be used on a 250 volt circuit where it is necessary to carry 200 amperes a distance of 350 feet to a center of distribution with a loss of 3 per cent. under full load?

3 per cent of 250 = 7.5 volts lost.

$\frac{350 \times 200 \times 21.5}{7.5}$ = 200667 circular mils, or No. 0000 B. & S. gauge, which is the next size heavier.

In using this or any other formula to determine the size of copper to use, care should be taken to see that the size adopted is not smaller than allowed in the Underwriters' table of safe carrying capacities, which are fixed without considering the loss in line.

The general practice in balanced 3-wire direct current systems with a central neutral wire is to figure the line loss on the same basis as a 2-wire system of the voltage between the two outside wires with the amount of current carried in the outside wires. The central neutral wire should be made the same size as either of the others.

## REASON WHY

For the benefit of those who care to know the reason why, the above Wiring Formula is based upon one foot of copper wire, with a cross-sectional area of one circular mil, having a resistance of very close to 10.75 ohms, so that the resistance of any copper wire =

$$\frac{\text{Length in feet} \times 10.75}{\text{Circular mils}}$$

Substituting this expression for R. in Ohm's Law:

$$E = \frac{C \times \text{length in feet} \times 10.75}{\text{Circular mils}}$$

and $$\text{Circular mils} = \frac{C \times \text{length in feet} \times 10.75}{E}$$

In the Wiring Formula, however, the length in feet is considered the "run," one side of the circuit, and the term 10.75 is multiplied by 2.

## ALTERNATING CURRENT FORMULAE

$$1 = \frac{W}{E \times P.F.} \text{ for single-phase circuit.}$$

$$1 = 0.50 \times \frac{W}{E \times P.F.} \text{ for two-phase circuit.}$$

$$1 = 0.58 \times \frac{W}{E \times P.F.} \text{ for three-phase circuit.}$$

1 = Current in line in amperes; W = energy delivered in watts; E = potential between mains in volts; P.F. = power factor. When power factor cannot be accurately determined it may be assumed as follows: Lighting load with no motors, 0.95; lighting and motors, 0.85; motors only, 0.80.

From the above formulae if W., E. and P.F. are the same it will be seen:

Current in each wire two-phase equals 0.5 current in each wire single-phase.

Current in each wire three-phase equals 0.58 current in each wire single-phase.

Current in each wire three-phase equals 1.16 current in each wire two-phase.

On alternating current systems of wiring, single-phase or 4-wire two-phase, that carry non-inductive loads, such as incandescent lamps, the printed wiring formula should be used, but where the load is inductive—motors or arc lamps—an addition of 25 per cent. to the number of circular mils obtained by the wiring formula is recommended, if the current required has been figured on the same basis as used for direct current, to compensate for the power factor. Single-phase 3-wire circuits may be figured on the same basis as direct current 3-wire, if non-conductive.

## THREE-PHASE WIRING

In a 3-wire balanced three-phase system the current in each wire of primary and secondary, to the point where the 3-wire system is divided into 2-wire, is 1.732 times the amount it would be if three separate single-phase circuits were used, owing to each wire having to carry current for two-phase.

For instance, in carrying 600 incandescent lamps, or 300 amperes—100 amperes on each phase—on 3-wire balanced three-phase secondary mains, the current in each of the three wires will be $100 \times 1.732$, or 173.2 amperes, and this quantity should be used in the wiring formula.

In other respects the three-phase 3-wire system may be figured the same as a 2-wire system, and each of the three wires made the same size.

Three-phase motors generally bear the manufacturer's name plate, showing amperes per phase, which represents the total current in each line wire, so that the multiplier of 1.732 should not be used to obtain size of copper.

In general:

$$\text{H. P.} = \frac{\text{amperes per phase} \times \text{volts} \times 1.732 \times \text{power factor}}{746}$$

$$\text{Amperes per phase} = \frac{\text{H. P.} \times 746}{\text{Volts} \times 1.732 \times \text{power factor}}$$

The term power factor is less than 1, and varies approximately from .65 for 1 H. P. to .90 for 50 H. P. motors.

In calculating the total load from switchboard voltmeters and ammeters:

Watts = amperes per phase × volts × 1.732 × power factor.

## WIRING FORMULA

Area of Conductor in C. M. $= K \frac{DxW}{PxE^2}$ Current in Main Conductor $= \frac{W}{E} T$

$P = K \frac{DxW}{CMxE^2}$ Weight of Copper $= \frac{D^2xWxKxA}{PxE^2x1{,}000{,}000}$ Pounds

W = Total Watts delivered.

D = Distance of transmission in feet one way.

E = Voltage between main conductors at consumer's end.

P = Loss in line in percentage of power delivered.

K, T, & A are given in the following table.

| System | Value of A | VALUE OF K Per Cent. Power Factor | | | | |
|---|---|---|---|---|---|---|
| | | 100 | 95 | 90 | 85 | 80 |
| 1 Phase D. C. | 6.04 | 2160 | 2400 | 2660 | 3000 | 3380 |
| 2 Phase 4 Wire | 12.08 | 1080 | 1200 | 1330 | 1500 | 1690 |
| 3 Phase 3 Wire | 9.06 | 1080 | 1200 | 1330 | 1500 | 1690 |

| System | Value of A | VALUE OF T Per Cent. Power Factor | | | | |
|---|---|---|---|---|---|---|
| | | 100 | 95 | 90 | 85 | 80 |
| 1 Phase D. C. | 6.04 | 1.00 | 1.05 | 1.11 | 1.17 | 1.25 |
| 2 Phase 4 Wire | 12.08 | .50 | .53 | .55 | .59 | .66 |
| 3 Phase 3 Wire | 9.06 | .58 | .61 | .64 | .68 | .72 |

The following tables show the amperes per phase taken by standard speed alternating current induction motors. Variation in speed will cause a difference in current consumption of as much as ten per cent.

## SINGLE-PHASE

| H. P. | 110 v Amps. | 220 v Amps. | 440 v Amps. | 550 v Amps. | 1100 v Amps. | 2080 v Amps. | 2200v Amps. |
|---|---|---|---|---|---|---|---|
| 1 | 12.0 | 5.8 | 2.8 | 2.2 | | | |
| 2 | 21.6 | 10.8 | 5.4 | 4.2 | | | |
| 3 | 30.6 | 16.2 | 8.0 | 6.2 | | | |
| 5 | 52.0 | 27.0 | 12.6 | 10.0 | | | |
| 7½ | 72.0 | 37.8 | 18.0 | 14.4 | | | |
| 10 | 100. | 50.4 | 24.4 | 20.0 | | | |
| 15 | 144. | 72.0 | 36.0 | 28.8 | | | |
| 20 | 189. | 90.0 | 45.0 | 36.0 | | | |
| 25 | 239. | 113. | 55.8 | 45.0 | | | |
| 30 | 270. | 135. | 70.0 | 54.0 | 28.8 | 18.0 | 14.4 |
| 40 | 360. | 184. | 92.0 | 72.0 | 38.0 | 21.6 | 19.8 |
| 50 | | 225. | 115. | 90.0 | 48.6 | 25.2 | 23.4 |
| 100 | | 450. | 226. | 180. | 90.0 | 48.6 | 50.4 |
| 150 | | 666. | 332. | 266. | 144. | 68.4 | 72.0 |
| 200 | | 864. | 440. | 360. | 176. | 95.4 | 88.2 |
| 250 | | 1054. | 528. | 428. | 226. | 117. | 111. |
| 300 | | 1306. | 648. | 522. | 270. | 144. | 133. |
| 450 | | | 972. | 770. | 404. | 228. | 206. |
| 675 | | | 1422. | 1124. | 608. | 312. | 304. |
| 1000 | | | 2124. | 1696. | 910. | 450. | 458. |

## TWO-PHASE

| H. P. | 110 v Amps. | 220 v Amps. | 440 v Amps. | 550 v Amps. | 1100 v Amps. | 2080 v Amps. | 2200 v Amps. |
|---|---|---|---|---|---|---|---|
| 1 | 6.0 | 2.9 | 1.4 | 1.1 | | | |
| 2 | 10.8 | 5.4 | 2.7 | 2.1 | | | |
| 3 | 15.3 | 8.1 | 4.0 | 3.1 | | | |
| 5 | 26.0 | 13.5 | 6.3 | 5.0 | | | |
| 7½ | 36.0 | 18.9 | 9.0 | 7.2 | | | |
| 10 | 50.0 | 25.2 | 12.2 | 10.0 | | | |
| 15 | 72.0 | 36.0 | 18.0 | 14.4 | | | |
| 20 | 94.5 | 45.0 | 22.5 | 18.0 | | | |
| 25 | 119. | 56.7 | 27.9 | 22.5 | | | |
| 30 | 135. | 67.5 | 35.0 | 27.0 | 14.4 | 9.0 | 7.2 |
| 40 | 180. | 91.8 | 46.0 | 36.0 | 19.0 | 10.8 | 9.9 |
| 50 | | 112. | 57.6 | 45.0 | 24.3 | 12.6 | 11.7 |
| 100 | | 225. | 113. | 90.0 | 45.0 | 24.3 | 25.2 |
| 150 | | 333. | 166. | 133. | 72.0 | 34.2 | 36.0 |
| 200 | | 432. | 220. | 180. | 88.0 | 47.7 | 44.1 |
| 250 | | 527. | 264. | 214. | 113. | 58.5 | 55.8 |
| 300 | | 653. | 324. | 261. | 135. | 72.0 | 66. 6 |
| 450 | | | 486. | 385. | 202. | 114. | 103. |
| 675 | | | 711. | 562. | 304. | 156. | 152. |
| 1000 | | | 1062. | 848. | 455. | 225. | 229. |

## THREE-PHASE

| H. P. | 110 v Amps. | 220 v Amps. | 440 v Amps. | 550 v Amps. | 1100 v Amps. | 2080 v Amps. | 2200 v Amps. |
|---|---|---|---|---|---|---|---|
| 1 | 6.5 | 3.2 | 1.6 | 1.3 | | | |
| 2 | 12.0 | 6.0 | 3.0 | 2.3 | | | |
| 3 | 17.0 | 9.0 | 4.5 | 3.5 | | | |
| 5 | 29.0 | 15.0 | 7.0 | 5.5 | | | |
| 7½ | 40.0 | 21.0 | 10.0 | 8.0 | | | |
| 10 | 55.0 | 28.0 | 13.5 | 11.0 | | | |
| 15 | 80.0 | 40.0 | 20.0 | 16.0 | | | |
| 20 | 105. | 50.0 | 25.0 | 20.0 | | | |
| 25 | 133. | 63.0 | 31.0 | 25.0 | | | |
| 30 | 150. | 75.0 | 39.0 | 30.0 | 16.0 | 10.0 | 8.0 |
| 40 | 200. | 102. | 51.0 | 40.0 | 21.0 | 12.0 | 11.0 |
| 50 | | 125. | 64.0 | 50.0 | 27.0 | 14.0 | 13.0 |
| 100 | | 250. | 125. | 100. | 50.0 | 27.0 | 28.0 |
| 150 | | 370. | 185. | 148. | 80.0 | 38.0 | 40.0 |
| 200 | | 480. | 244. | 200. | 98.0 | 53.0 | 49.0 |
| 250 | | 586. | 293. | 238. | 125. | 65.0 | 62.0 |
| 300 | | 725. | 360. | 290. | 150. | 80.0 | 74.0 |
| 450 | | | 540. | 428. | 225. | 116. | 114. |
| 675 | | | 790. | 625. | 338. | 173. | 169. |
| 1000 | | | 1180. | 942. | 506. | 250. | 254. |

## BARE COPPER WIRE—Resistance Calculated at 20° C. or 68° F.

| A. W. G. | Ohms per 1000 Ft. | Ohms per Mile | Feet per Ohm | Ohms per Pound |
|---|---|---|---|---|
| 0000 | .049 0 | .259 | 20 440. | .000 076 4 |
| 000 | .061 8 | .326 | 16 210. | .000 121 5 |
| 00 | .077 9 | .411 | 12 850. | .000 193 1 |
| 0 | .098 3 | .519 | 10 190. | .000 307 1 |
| 1 | .123 9 | .654 | 8 083. | .000 488 3 |
| 2 | .156 3 | .825 | 6 410. | .000 776 5 |
| 3 | .197 0 | 1.040 | 5 084. | .001 235 |
| 4 | .248 5 | 1.312 | 4 031. | .001 963 |
| 5 | .313 3 | 1.654 | 3 197. | .003 122 |
| 6 | .395 1 | 2.086 | 2 535. | .004 963 |
| 7 | .498 2 | 2.630 | 2 001. | .007 892 |
| 8 | .628 2 | 3.317 | 1 595. | .012 55 |
| 9 | .792 1 | 4.182 | 1 265. | .019 95 |
| 10 | .998 9 | 5.274 | 1 003. | .031 73 |
| 11 | 1.260 | 6.650 | 795.3 | .050 45 |
| 12 | 1.588 | 8.386 | 630.7 | .080 22 |
| 13 | 2.003 | 10.57 | 500.1 | .127 6 |
| 14 | 2.525 | 13.33 | 396.6 | .202 8 |
| 15 | 3.184 | 16.81 | 314.5 | .322 5 |
| 16 | 4.016 | 21.20 | 249.4 | .512 8 |
| 17 | 5.064 | 26.74 | 197.8 | .815 3 |
| 18 | 6.385 | 33.71 | 156.9 | 1.296 |
| 19 | 8.051 | 42.51 | 124.4 | 2.061 |
| 20 | 10.15 | 53.61 | 98.66 | 3.278 |
| 21 | 12.80 | 67.60 | 78.24 | 5.212 |
| 22 | 16.14 | 85.24 | 62.05 | 8.287 |
| 23 | 20.36 | 107.5 | 49.21 | 13.18 |
| 24 | 25.67 | 135.5 | 39.02 | 20.95 |
| 25 | 32.37 | 170.9 | 30.95 | 33.32 |
| 26 | 40.81 | 215.5 | 24.54 | 52.97 |
| 27 | 51.47 | 271.7 | 19.46 | 84.23 |
| 28 | 64.90 | 342.7 | 15.43 | 133.9 |
| 29 | 81.84 | 432.1 | 12.24 | 213.0 |
| 30 | 103.2 | 544.9 | 9.707 | 338.6 |
| 31 | 130.1 | 687.0 | 7.698 | 538.4 |
| 32 | 164.1 | 866.4 | 6.105 | 856.2 |

## BARE COPPER WIRE
### Dimensions and Weights

| A. W. G. | Diameter Mils | Circular Mils | Lbs. per 1000 ft. | Lbs. per Mile |
|---|---|---|---|---|
| 0000 | 460.0000 | 211 600.00 | 640.5 | 3 382. |
| 000 | 409.6431 | 167 772.16 | 507.8 | 2 682. |
| 00 | 364.7977 | 133 079.04 | 402.8 | 2 127. |
| 0 | 324.8617 | 105 560.01 | 319.5 | 1 687. |
| 1 | 289.2977 | 83 694.49 | 253.3 | 1 338. |
| 2 | 257.6270 | 66 357.76 | 200.9 | 1 061. |
| 3 | 229.4235 | 52 624.36 | 159.3 | 841.2 |
| 4 | 204.3075 | 41 738.49 | 126.3 | 667.1 |
| 5 | 181.9411 | 33 087.61 | 100.2 | 529.1 |
| 6 | 162.0232 | 26 244.00 | 79.44 | 419.6 |
| 7 | 144.2858 | 20 822.49 | 63.03 | 332.7 |
| 8 | 128.4902 | 16 512.25 | 49.98 | 263.9 |
| 9 | 114.4238 | 13 087.36 | 39.61 | 209.3 |
| 10 | 101.8973 | 10 383.61 | 31.43 | 165.9 |
| 11 | 90.7432 | 8 226.49 | 24.90 | 131.6 |
| 12 | 80.8083 | 6 528.64 | 19.76 | 104.4 |
| 13 | 71.9619 | 5 184.00 | 15.69 | 82.77 |
| 14 | 64.0839 | 4 108.81 | 12.44 | 65.64 |
| 15 | 57.0684 | 3 260.41 | 9.869 | 52.05 |
| 16 | 50.8209 | 2 580.64 | 7.812 | 41.28 |
| 17 | 45.2573 | 2 052.09 | 6.212 | 32.74 |
| 18 | 40.3028 | 1 624.09 | 4.916 | 25.96 |
| 19 | 35.8907 | 1 288.81 | 3.901 | 20.59 |
| 20 | 31.9616 | 1 024.00 | 3.100 | 16.33 |
| 21 | 28.4626 | 812.25 | 2.459 | 12.95 |
| 22 | 25.3467 | 640.09 | 1.938 | 10.27 |
| 23 | 22.5719 | 510.76 | 1.546 | 8.143 |
| 24 | 20.1009 | 404.01 | 1.223 | 6.458 |
| 25 | 17.9004 | 320.41 | .9699 | 5.121 |
| 26 | 15.9408 | 252.81 | .7652 | 4.061 |
| 27 | 14.1957 | 201.64 | .6104 | 3.221 |
| 28 | 12.6416 | 158.76 | .4806 | 2.554 |
| 29 | 11.2577 | 127.69 | .3865 | 2.026 |
| 30 | 10.0253 | 100.00 | .3027 | 1.606 |
| 31 | 8.9278 | 79.21 | .2398 | 1.274 |
| 32 | 7.9504 | 64.00 | .1937 | 1.010 |

## AMPERES PER MOTOR

Direct Current

| H. P. | % Efficiency | Watts | 110v | 115v | 120v | 125v | 220v | 250v | 500v | 525v | 550v |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ¾ | 65 | 860 | 7.8 | 7.5 | 7.2 | 6.9 | 3.9 | 3.4 | 1.7 | 1.6 | 1.6 |
| 1 | 65 | 1 148 | 10.4 | 10.0 | 9.6 | 9.2 | 5.2 | 4.6 | 2.3 | 2.2 | 2.1 |
| 2 | 65 | 2 295 | 20.8 | 20.0 | 19.1 | 18.4 | 10.4 | 9.2 | 4.6 | 4.4 | 4.2 |
| 2½ | 75 | 2 487 | 22.6 | 21.6 | 20.7 | 19.9 | 11.3 | 10.0 | 5.0 | 4.7 | 4.5 |
| 3½ | 75 | 3 480 | 31.6 | 30.3 | 29.0 | 27.8 | 15.8 | 13.9 | 7.0 | 6.6 | 6.3 |
| 5 | 80 | 4 662 | 42.4 | 40.5 | 38.8 | 37.3 | 21.2 | 18.6 | 9.3 | 8.9 | 8.5 |
| 7½ | 80 | 6 994 | 63.6 | 60.8 | 58.3 | 56.0 | 31.8 | 28.0 | 14.0 | 13.3 | 12.7 |
| 10 | 85 | 8 776 | 79.8 | 76.3 | 73.1 | 70.2 | 39.9 | 35.1 | 17.6 | 16.7 | 16.0 |
| 15 | 85 | 13 165 | 120. | 114. | 110. | 105. | 59.8 | 52.6 | 26.3 | 25.1 | 23.9 |
| 20 | 90 | 16 578 | 151. | 144. | 138. | 133. | 75.4 | 66.3 | 33.2 | 31.6 | 30.1 |
| 25 | 90 | 20 722 | 188. | 180. | 173. | 166. | 94.2 | 82.9 | 41.4 | 39.5 | 37.7 |
| 30 | 90 | 24 867 | 226. | 216. | 207. | 199. | 113. | 99.4 | 49.7 | 47.4 | 45.2 |
| 40 | 90 | 33 155 | 301. | 288. | 276. | 265. | 151. | 133. | 66.3 | 63.2 | 60.3 |
| 50 | 90 | 41 444 | 377. | 360. | 345. | 332. | 188. | 166. | 82.9 | 79.0 | 75.4 |
| 70 | 90 | 58 022 | 528. | 505. | 484. | 464. | 264. | 232. | 116. | 111. | 106. |
| 90 | 90 | 74 600 | 678. | 649. | 622. | 597. | 339. | 298. | 149. | 142. | 136. |
| 100 | 93 | 80 215 | 729. | 697. | 668. | 642. | 365. | 321. | 160. | 153. | 146. |
| 125 | 93 | 100 269 | 912. | 872. | 836. | 802. | 456. | 401. | 200. | 191. | 182. |
| 150 | 93 | 120 323 | 1094. | 1046. | 1003. | 963. | 547. | 481. | 241. | 229. | 219. |

## NUMBER OF WIRES IN STRANDS, B. & S. GAUGE

| Circular Mils | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000000 | 121 | 153 | 193 | 243 | 306 | 386 | 487 | 614 | 774 | 976 | 1231 | 1553 | 1958 | 2469 | 3113 | 3926 | 4950 |
| 1750000 | 106 | 134 | 169 | 213 | 268 | 338 | 426 | 537 | 678 | 854 | 1077 | 1359 | 1713 | 2160 | 2724 | 3435 | 4331 |
| 1500000 | 91 | 115 | 144 | 182 | 230 | 290 | 365 | 461 | 581 | 732 | 923 | 1164 | 1468 | 1852 | 2335 | 2944 | 3712 |
| 1250000 | 76 | 95 | 120 | 152 | 191 | 241 | 304 | 384 | 484 | 610 | 770 | 970 | 1224 | 1543 | 1946 | 2453 | 3094 |
| 1000000 | 61 | 76 | 96 | 121 | 153 | 193 | 244 | 307 | 387 | 488 | 616 | 776 | 979 | 1234 | 1557 | 1963 | 2475 |
| 950000 | 58 | 73 | 91 | 115 | 145 | 183 | 231 | 292 | 368 | 464 | 585 | 738 | 930 | 1173 | 1479 | 1865 | 2351 |
| 900000 | 55 | 69 | 87 | 109 | 138 | 174 | 219 | 276 | 348 | 439 | 554 | 699 | 881 | 1111 | 1401 | 1766 | 2227 |
| 850000 | 51 | 65 | 82 | 103 | 130 | 164 | 207 | 261 | 329 | 415 | 523 | 660 | 832 | 1049 | 1323 | 1668 | 2104 |
| 800000 | 48 | 61 | 77 | 97 | 123 | 154 | 195 | 246 | 310 | 391 | 493 | 621 | 783 | 988 | 1245 | 1570 | 1980 |
| 750000 | 45 | 57 | 72 | 91 | 115 | 145 | 183 | 230 | 290 | 366 | 462 | 582 | 734 | 926 | 1167 | 1472 | 1856 |
| 700000 | 42 | 53 | 67 | 85 | 107 | 135 | 170 | 215 | 271 | 342 | 431 | 543 | 685 | 864 | 1090 | 1374 | 1732 |
| 650000 | 39 | 50 | 63 | 79 | 100 | 126 | 158 | 200 | 252 | 317 | 400 | 505 | 636 | 802 | 1012 | 1276 | 1609 |
| 600000 | 36 | 46 | 58 | 73 | 92 | 116 | 146 | 184 | 232 | 293 | 369 | 466 | 587 | 741 | 934 | 1178 | 1485 |
| 550000 | 33 | 42 | 53 | 67 | 84 | 106 | 134 | 169 | 213 | 269 | 339 | 427 | 538 | 679 | 856 | 1080 | 1361 |
| 500000 | 30 | 38 | 48 | 61 | 77 | 97 | 122 | 154 | 194 | 244 | 308 | 388 | 489 | 617 | 778 | 981 | 1237 |
| 450000 | 27 | 34 | 43 | 55 | 69 | 87 | 110 | 138 | 174 | 220 | 277 | 349 | 441 | 555 | 700 | 883 | 1114 |
| 400000 | 24 | 31 | 39 | 49 | 61 | 77 | 97 | 123 | 155 | 195 | 246 | 311 | 392 | 494 | 623 | 785 | 990 |
| 350000 | 21 | 27 | 34 | 43 | 54 | 68 | 85 | 107 | 136 | 171 | 215 | 272 | 343 | 432 | 545 | 687 | 866 |
| 300000 | 18 | 23 | 29 | 36 | 46 | 58 | 73 | 92 | 116 | 146 | 185 | 233 | 294 | 370 | 467 | 589 | 742 |
| 250000 | 15 | 19 | 24 | 30 | 38 | 48 | 61 | 77 | 97 | 122 | 154 | 194 | 245 | 309 | 389 | 491 | 619 |

## NUMBER OF WIRES IN STRANDS, B. & S. GAUGE

| Size Strand | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4–0 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 | 1324 | 1670 | 2106 | 2655 | 3348 | 4220 | 5324 | 6712 | 8464 |
| 3–0 | 164 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 | 1324 | 1670 | 2106 | 2655 | 3348 | 4220 | 5324 | 6712 |
| 2–0 | 130 | 164 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 | 1324 | 1670 | 2106 | 2655 | 3348 | 4220 | 5324 |
| 1–0 | 103 | 130 | 164 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 | 1324 | 1670 | 2106 | 2655 | 3348 | 4220 |
| 1 | 82 | 103 | 130 | 164 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 | 1324 | 1670 | 2106 | 2655 | 3348 |
| 2 | 65 | 82 | 103 | 130 | 164 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 | 1324 | 1670 | 2106 | 2655 |
| 3 | 52 | 65 | 82 | 103 | 130 | 164 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 | 1324 | 1670 | 2106 |
| 4 | 41 | 52 | 65 | 82 | 103 | 130 | 164 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 | 1324 | 1670 |
| 5 | 32 | 41 | 52 | 65 | 82 | 103 | 130 | 164 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 | 1324 |
| 6 | 26 | 32 | 41 | 52 | 65 | 82 | 103 | 130 | 164 | 207 | 261 | 330 | 415 | 524 | 660 | 833 | 1050 |
| 8 | 16 | 20 | 26 | 32 | 41 | 52 | 65 | 82 | 103 | 130 | 164 | 207 | 261 | 330 | 415 | 524 | 660 |
| 9 | 13 | 16 | 20 | 26 | 32 | 41 | 52 | 65 | 82 | 103 | 130 | 164 | 207 | 261 | 330 | 415 | 524 |
| 10 | 10 | 13 | 16 | 20 | 26 | 32 | 41 | 52 | 65 | 82 | 103 | 130 | 164 | 207 | 261 | 330 | 415 |
| 12 | 6.4 | 8 | 10 | 13 | 16 | 20 | 26 | 32 | 41 | 52 | 65 | 82 | 103 | 130 | 164 | 207 | 261 |
| 14 | 4.0 | 5.1 | 6.4 | 8 | 10 | 13 | 16 | 20 | 26 | 32 | 41 | 52 | 65 | 82 | 103 | 130 | 164 |
| 16 | 2.5 | 3.2 | 4.0 | 5.1 | 6.4 | 8 | 10 | 13 | 16 | 20 | 26 | 32 | 41 | 52 | 65 | 82 | 103 |
| 18 | 1.6 | 2.0 | 2.5 | 3.2 | 4.0 | 5.1 | 6.4 | 8 | 10 | 13 | 16 | 20 | 26 | 32 | 41 | 52 | 65 |
| 20 | 1.0 | 1.3 | 1.6 | 2.0 | 2.5 | 3.2 | 4.0 | 5.1 | 6.4 | 8 | 10 | 13 | 16 | 20 | 26 | 32 | 41 |
| 22 | | | 1.0 | 1.3 | 1.6 | 2.0 | 2.5 | 3.2 | 4.0 | 5.1 | 6.4 | 8 | 10 | 13 | 16 | 20 | 26 |

## UNDERWRITERS' RULES FOR SPACING OF SWITCHES—125 VOLTS OR LESS

### For Switch and Panel Boards

| | Separation of Nearest Metal Parts of Opposite Polarity. | Minimum Break Distance. |
|---|---|---|
| 10 amperes or less | ¾ inch | ½ inch |
| 11-25 amperes | 1 inch | ¾ inch |
| 26-50 amperes | 1¼ inch | 1 inch |

### For Individual Switches

| | | |
|---|---|---|
| 10 amperes or less | 1 inch | ¾ inch |
| 11-35 amperes | 1¼ inch | 1 inch |
| 36-100 amperes | 1½ inch | 1¼ inch |
| 101-300 amperes | 2¼ inch | 2 inch |
| 301-600 amperes | 2¾ inch | 2½ inch |
| 601-1000 amperes | 3 inch | 2¾ inch |

### FOR ALL SWITCHES

#### 125 to 250 Volts

| | | |
|---|---|---|
| 10 amperes or less | 1½ inch | 1¼ inch |
| 11-35 amperes | 1¾ inch | 1½ inch |
| 36-100 amperes | 2¼ inch | 2 inch |
| 101-300 amperes | 2½ inch | 2¼ inch |
| 301-600 amperes | 2¾ inch | 2½ inch |
| 601-1000 amperes | 3 inch | 2¾ inch |

#### 250 to 600 Volts

| | | |
|---|---|---|
| 10 amperes or less | 3½ inch | 3 inch |
| 11-35 amperes | 4 inch | 3½ inch |
| 36-100 amperes | 4½ inch | 4 inch |

Auxiliary breaks or equivalent are recommended for switches designed for over 300 volts, and less than 100 amperes, and will be required on switches designed *for use in breaking currents* over 100 amperes, at a pressure of more than 300 volts.

On switchboards, the above spacings for 250 volts direct current are also approved for 440 volts alternating current. Switches on switchboards with these spacings, intended for use on alternating-current systems with voltage above 250 volts, must be stamped with the voltage for which they are designed, followed by the letters "A. C."

For three-wire systems, switches must have the break distance required for circuits of the potential of the outside wires.

## GALVANIZED IRON WIRE

Weight and Resistance Calculated at 68°F.

| B.W. Gauge | Diameter in Mils. | Approx. Pounds per Mile | Ohms Resistance per Mile | | |
|---|---|---|---|---|---|
| | | | E.B.B. | B.B. | Steel |
| 4 | 238 | 811 | 5.80 | 6.91 | 8.01 |
| 6 | 203 | 590 | 7.97 | 9.49 | 11.02 |
| 8 | 165 | 390 | 12.05 | 14.36 | 16.71 |
| 9 | 148 | 314 | 14.97 | 17.84 | 20.70 |
| 10 | 134 | 258 | 18.22 | 21.71 | 25.29 |
| 11 | 120 | 206 | 22.82 | 27.19 | 31.55 |
| 12 | 109 | 170 | 27.65 | 32.94 | 38.23 |
| 14 | 083 | 99 | 47.48 | 56.56 | 65.66 |

The breaking weight of any size of iron or steel wire, annealed and galvanized, is about equal to the weight per mile in pounds, multiplied for E. B. B., by 3; for B. B., by 3.33; and for steel, by 3.75.

## STANDARD GRADES

There are three standards of extra galvanized telephone and telegraph wire in general commercial use:

"EXTRA BEST BEST" (E. B. B.) stands highest in conductivity of any telegraph wire with a weight per mile ohm of from 4700 to 5000 pounds.

"BEST BEST" (B. B.) is superior to the E. B. B. in mechanical qualities and equal in galvanizing, but of somewhat lower electrical value. Weight per mile ohm, 5600 to 6000 pounds.

"STEEL" (or homogeneous metal) has a very high tensile strength, and a weight per mile ohm of 6500 to 7000 pounds.

## MELTING POINT AND RELATIVE ELECTRICAL CONDUCTIVITY OF DIFFERENT METALS AND ALLOYS

| Metals. | Relative Conductivity | Melting Point °F. |
|---|---|---|
| Pure silver | 100. | 1873 |
| Pure copper | 100. | 2550 |
| Refined and crystallized copper | 99.9 | |
| Telegraphic silicious bronze | 98. | |
| Alloy of copper and silver (50%) | 86.65 | |
| Pure gold | 78. | 2016 |
| Silicide of copper, 4% Si | 75. | |
| Silicide of copper, 12% Si | 54.7 | |
| Pure aluminum | 54.2 | 1160 |
| Tin with 12% of sodium | 46.9 | |
| Telephonic silicious bronze | 35. | |
| Copper with 10% of lead | 30. | |
| Pure zinc | 29.9 | 773 |
| Telephonic phosphor-bronze | 29. | |
| Silicious brass, 25% zinc | 26.49 | |
| Brass with 35% zinc | 21.5 | |
| Phosphor tin | 17.7 | |
| Alloy of gold and silver (50%) | 16.12 | |
| Swedish iron | 16. | 4000 |
| Pure Banca Tin | 15.45 | 442 |
| Antimonial copper | 12.7 | |
| Aluminum bronze (10%) | 12.6 | |
| Siemens steel | 12. | |
| Pure platinum | 10.6 | 4100 |
| Copper with 10% of nickel | 10.6 | |
| Cadmium Amalgam (15%) | 10.2 | |
| Dronier mercurial bronze | 10.14 | |
| Arsenical copper (10%) | 9.1 | |
| Pure lead | 8.88 | 630 |
| Bronze with 20% of tin | 8.4 | |
| Pure nickel | 7.89 | 2800 |
| Phosphor-bronze, 10% tin | 6.5 | |
| Phosphor-copper, 9% phos | 4.9 | |
| Antimony | 3.88 | 840 |

## BUSBAR COPPER DATA

| Thickness Inches. | Width Inches. | Weight per Lineal Ft | Carrying Capacity. @ 1000 Amp. | Carrying Capacity. @ 800 Amp. |
|---|---|---|---|---|
| 1/16 | ½ | .121 | 31 | 25 |
| 1/16 | ¾ | .181 | 47 | 38 |
| 1/16 | 1 | .241 | 63 | 50 |
| 1/8 | ½ | .241 | 63 | 50 |
| 1/8 | ¾ | .362 | 94 | 75 |
| 1/8 | 1 | .482 | 125 | 100 |
| 1/8 | 1¼ | .603 | 156 | 125 |
| 1/8 | 1½ | .723 | 188 | 150 |
| 1/8 | 1¾ | .844 | 219 | 175 |
| 1/8 | 2 | .964 | 250 | 200 |
| 1/8 | 2½ | 1.21 | 313 | 250 |
| 1/8 | 3 | 1.45 | 375 | 300 |
| 1/4 | ½ | .482 | 125 | 100 |
| 1/4 | ¾ | .723 | 188 | 150 |
| 1/4 | 1 | .964 | 250 | 200 |
| 1/4 | 1¼ | 1.21 | 313 | 250 |
| 1/4 | 1½ | 1.45 | 375 | 300 |
| 1/4 | 1¾ | 1.69 | 438 | 350 |
| 1/4 | 2 | 1.93 | 500 | 400 |
| 1/4 | 2½ | 2.41 | 625 | 500 |
| 1/4 | 3 | 2.89 | 750 | 600 |
| 3/8 | 1 | 1.45 | 375 | 300 |
| 3/8 | 1¼ | 1.81 | 469 | 375 |
| 3/8 | 1½ | 2.17 | 563 | 450 |
| 3/8 | 1¾ | 2.53 | 657 | 525 |
| 3/8 | 2 | 2.89 | 750 | 600 |
| 3/8 | 2½ | 3.62 | 938 | 750 |
| 3/8 | 3 | 4.34 | 1125 | 900 |

## GENERAL SUGGESTIONS

In all electric work, conductors, however well insulated, should always be treated as bare to the end that under no conditions, existing or likely to exist, can a ground or short circuit occur, and so that all leakage from conductor to conductor, or between conductor and ground, may be reduced to the minimum.

In all wiring special attention must be paid to the mechanical execution of the work. Careful and neat running, connecting, soldering, taping of conductors, and securing and attaching of fittings, are specially conducive to security and efficiency, and will be strongly insisted on.

In laying out an installation, except for constant current systems, every reasonable effort should be made to secure distribution centers located in easily accessible places, at which points the cutouts and switches controlling the several branch circuits can be grouped for convenience and safety of operation. The load should be divided as evenly as possible among the branches, and all complicated and unnecessary wiring avoided.

## DIAMETERS OF CONDUITS

Various Sizes Required for One, Two and Three Wires

| No. B. & S. Gauge | Circular Mils | Amps. Rubber | Size of Pipe | | |
|---|---|---|---|---|---|
| | | | 1 Wire | 2 Wire | 3 Wire |
| 14 | 4108.81 | 15 | ½ | ½ | ½ |
| 12 | 6528.64 | 20 | ½ | ¾ | ¾ |
| 10 | 10383.61 | 25 | ½ | ¾ | ¾ |
| 8 | 16512.25 | 35 | ½ | 1 | 1 |
| 6 | 26244.00 | 50 | ½ | 1 | 1¼ |
| 5 | 33087.61 | 55 | ¾ | 1¼ | 1¼ |
| 4 | 41738.49 | 70 | ¾ | 1¼ | 1¼ |
| 3 | 52624.36 | 80 | ¾ | 1¼ | 1¼ |
| 2 | 66357.76 | 90 | ¾ | 1¼ | 1½ |
| 1 | 83694.49 | 100 | ¾ | 1½ | 1½ |
| 0 | 105560.01 | 125 | 1 | 1½ | 2 |
| 00 | 133079.04 | 150 | 1 | 2 | 2 |
| 000 | 167772.16 | 175 | 1 | 2 | 2 |
| 0000 | 211600.00 | 200 | 1¼ | 2 | 2½ |
| | 250000 | 240 | 1¼ | 2½ | 2½ |
| | 300000 | 275 | 1¼ | 2½ | 2½ |
| | 350000 | 300 | 1¼ | 3 | 3 |
| | 400000 | 325 | 1¼ | 3 | 3 |
| | 450000 | 370 | 1½ | 3 | 3 |
| | 500000 | 400 | 1½ | 3 | 3 |
| | 600000 | 450 | 1½ | 3 | 3½ |
| | 700000 | 500 | 2 | 3½ | 3½ |
| | 800000 | 550 | 2 | 3½ | 4 |
| | 900000 | 600 | 2 | 3½ | 4 |
| | 1000000 | 650 | 2 | 4 | 4 |
| | 1250000 | 750 | 2½ | 4½ | 4½ |
| | 1500000 | 850 | 2½ | 4½ | 5 |
| | 1750000 | 950 | 3 | 5 | 5 |
| | 2000000 | 1050 | 3 | 5 | 6 |

In laying out a conduit job, first ascertain the size and number of wires required, then take the sizes of conduit from the above table. One-half inch is usually used for branch conduits and is the smallest size permitted by the National Electric Code. In running several conduits together, a pull box will be found more economical than elbows for making turns, as one pull box will take the place of several elbows.

Do not pull wires through conduits with a block and tackle, as it will not only injure the insulation, but wedge the wires in such shape that they cannot be removed readily if desired.

Be careful to ream out the end when conduit is cut, as the burr may otherwise cut through the insulation.

Conduits should be securely fastened to walls and ceiling by use of pipe straps or hooks.

Plug all exposed ends of conduit in new buildings to prevent plaster and dirt from falling into it.

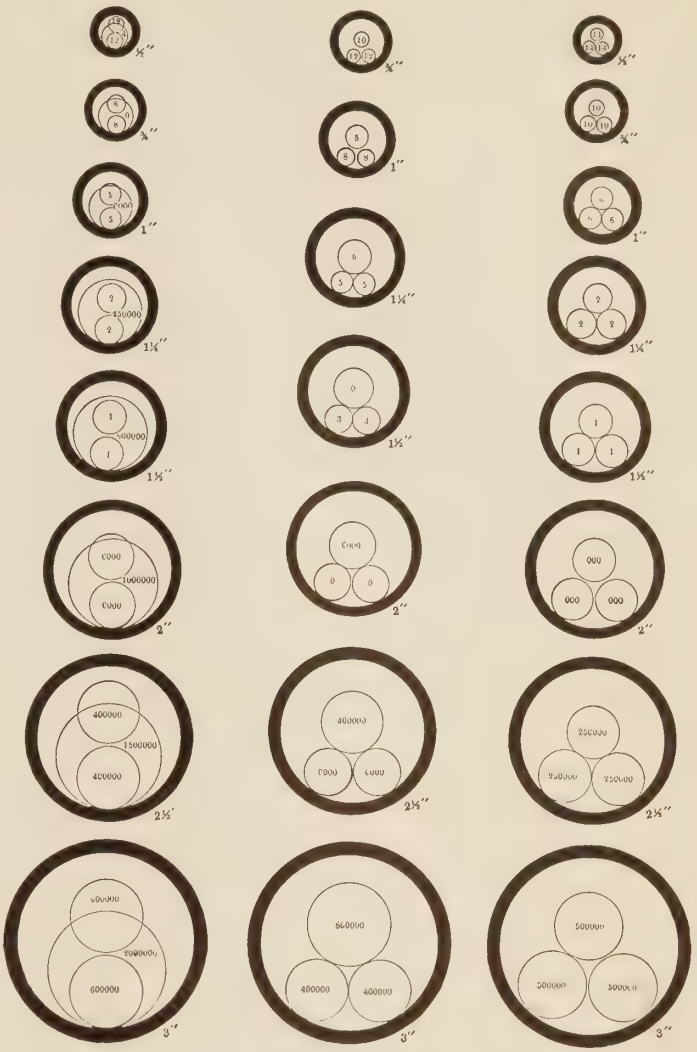
## CONDUCTORS AND INSULATORS IN ORDER OF THEIR VALUE

| Conductors | Insulators (Non-Conductors) | |
|---|---|---|
| All metals | Dry air | Ebonite |
| Well-burned charcoal | Shellac | Gutta-percha |
| Plumbago | Paraffin | India-rubber |
| Acid solutions | Amber | Silk |
| Saline solutions | Resins | Dry paper |
| Metallic ores | Sulphur | Parchment |
| Animal fluids | Wax | Dry leather |
| Living vegetable substances | Jet | Porcelain |
| Moist earth | Glass Oils | |
| Water | Mica | |

According to Culley the resistance of distilled water is 6,754 million times as great as that of copper.

## Conduit and Wire Diagram

Showing actual relation of various sizes double braid rubber covered wire to conduit



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## SAG IN WIRES

In the following tables are given the sags and tensions for copper and aluminum cables of various sizes. If the cables are strung with the sag and tension and at the temperature indicated without wind, then with the worst conditions of sleet, wind and temperature given at the head of each table, the tension will just equal the elastic limit of the cable. It will be noted that definite spans have been chosen for each size of conductors. This has been an arbitrary choice based on reasonable values of sag. The matter of economy would in many cases demand that other spans be used, but it has not been practicable to give, in these tables, the sags corresponding to a great number of spans. The scope of these tables is, therefore, more or less limited, being useful when accurate values are wanted only for the spans indicated. To determine roughly what the sag would be at other spans, for the purpose say of approximating the height of the towers, the following equation may be used

$$\frac{\text{Sag}_1}{\text{Sag}_2} = \frac{\text{Span}^2_1}{\text{Span}^2_2}$$

When going from a smaller span to a larger span this equation gives too small a sag and vice versa, when going from a larger to a smaller span the equation will give too large a sag. Even for the determination of approximate sags this equation cannot be used in changing from one span to another over a very great range, such as from 600 ft. to 1000 ft. spans. The error for such a change is entirely too great.

If it is desired to obtain approximately the tension corresponding to a given sag the following equation can be used

$$\text{Tension} = \frac{\text{Span}^2 \times \text{weight per ft. of conductor}}{8 \times \text{sag}}$$

## SAGS AND TENSIONS FOR COPPER CABLES

(Worst Condition: 0° F., ½ in. Ice, 8 lb. Wind)

| Size (B. & S.) | Span (Ft.) | *Allowable Stress in Lb. | CONDITIONS WITHOUT ICE OR WIND — SAG IN FEET 0° | 60° | 80° | 130° | STRESS IN LB. (TOTAL) 0° | 60° | 80° | 130° |
|---|---|---|---|---|---|---|---|---|---|---|
| 300,000 | 600 | 6900 | 9.37 | 11.57 | 12.40 | 14.25 | 4560 | 3700 | 3455 | 3010 |
| 250,000 | 600 | 5810 | 9.96 | 12.22 | 13.02 | 14.82 | 3530 | 2890 | 2705 | 2375 |
| 0000 | 600 | 4850 | 11.32 | 13.58 | 14.31 | 16.02 | 2637 | 2205 | 2090 | 1867 |
| 000 | 600 | 3870 | 13.20 | 15.37 | 16.18 | 17.72 | 1795 | 1547 | 1480 | 1337 |
| 00 | 600 | 3100 | 16.03 | 17.95 | 18.55 | 20.05 | 1179 | 1049 | 1016 | 941 |
| 0 | 600 | 2460 | 19.63 | 21.33 | 21.90 | 23.30 | 764 | 701 | 685 | 645 |
| 0 | 500 | 2460 | 12.10 | 14.10 | 14.65 | 15.95 | 837 | 733 | 708 | 652 |
| 1 | 500 | 1953 | 15.60 | 17.10 | 17.55 | 18.75 | 527 | 481 | 463 | 440 |
| 2 | 500 | 1523 | 20.20 | 21.50 | 21.85 | 22.85 | 325 | 307 | 301 | 288 |
| 3 | 300 | 1223 | 7.02 | 8.20 | 8.56 | 9.36 | 266 | 229 | 219 | 200 |
| 4 | 300 | 972 | 9.48 | 10.29 | 10.56 | 11.34 | 157 | 143 | 140 | 130 |
| 5 | 300 | 774 | 12.36 | 13.12 | 13.35 | 13.94 | 95 | 90 | 88 | 85 |
| 6 | 200 | 614 | 6.00 | 6.64 | 6.84 | 7.34 | 69 | 62 | 61 | 56 |

*Allowable stress—one-half ultimate strength. Sags and tensions calculated to give allowable stress under worst conditions specified above. Coeff. of expansion—0.0000096. Modulus of elasticity —16,000,000.

## SAGS AND TENSIONS FOR COPPER CABLES

(Worst Condition: 20° F., no Ice, 15 lb. Wind)

| Size (B. & S.) | Span (Ft.) | *Allowable Stress in Lb. | CONDITIONS WITHOUT ICE OR WIND — SAG IN FEET 20° | 70° | 100° | 130° | STRESS IN LB. (TOTAL) 20° | 70° | 100° | 130° |
|---|---|---|---|---|---|---|---|---|---|---|
| 300,000 | 600 | 6900 | 6.72 | 8.28 | 9.36 | 10.51 | 6340 | 5160 | 4580 | 4085 |
| 250,000 | 600 | 5810 | 6.685 | 8.245 | 9.30 | 10.44 | 5260 | 4270 | 3790 | 3380 |
| 0000 | 600 | 4850 | 6.92 | 8.52 | 9.6 | 10.72 | 4310 | 3515 | 3125 | 2790 |
| 000 | 600 | 3870 | 7.08 | 8.70 | 9.78 | 10.89 | 3330 | 2710 | 2410 | 2175 |
| 00 | 600 | 3100 | 7.32 | 8.88 | 9.99 | 11.10 | 2570 | 2110 | 1882 | 1695 |
| 0 | 500 | 2460 | 5.00 | 6.35 | 7.20 | 8.182 | 2065 | 1635 | 1433 | 1264 |
| 1 | 500 | 1953 | 5.235 | 6.565 | 7.55 | 8.50 | 1557 | 1244 | 1087 | 961 |
| 2 | 500 | 1523 | 5.65 | 7.10 | 8.075 | 9.10 | 1147 | 914 | 803 | 713 |
| 3 | 300 | 1223 | 1.74 | 2.29 | 2.82 | 3.49 | 1004 | 793 | 652 | 536 |
| 4 | 300 | 972 | 1.80 | 2.37 | 2.97 | 3.60 | 811 | 603 | 493 | 399 |

*Allowable stress—one-half ultimate strength. Sags and tensions calculated to give allowable stress under worst conditions specified above. Coeff. of expansion—0.0000096. Modulus of elasticity—16,000,000.

## SAGS AND TENSIONS FOR ALUMINUM CABLES

(Worst Condition: 0° F., ½ in. Ice, 8 lb. Wind)

| Size (Copper Equivalent) | Span (Ft.) | †Allowable Stress in Lb. | CONDITIONS WITHOUT ICE OR WIND — SAG IN FEET 0° | 60° | 80° | 130° | STRESS IN LB. (TOTAL) ° | 60° | 80° | 130° |
|---|---|---|---|---|---|---|---|---|---|---|
| 350,000 | 600 | 6120 | 8.28 | 11.98 | 13.12 | 15.81 | 2775 | 1923 | 1752 | 1465 |
| 300,000 | 600 | 5250 | 9.63 | 13.28 | 14.35 | 16.86 | 2053 | 1495 | 1383 | 1183 |
| 250,000 | 600 | 4380 | 11.71 | 14.95 | 16.02 | 18.31 | 1412 | 1105 | 1032 | 903 |
| 0000 | 600 | 3705 | 13.94 | 16.87 | 17.83 | 20.05 | 1006 | 834 | 791 | 709 |
| 000 | 600 | 2932 | 17.77 | 20.40 | 21.12 | 23.04 | 629 | 551 | 530 | 487 |
| 00 | 500 | 2330 | 14.10 | 16.40 | 17.12 | 18.67 | 435 | 377 | 361 | 331 |
| 0 | 500 | 1843 | 18.45 | 20.10 | 20.62 | 22.15 | 266 | 245 | 238 | 223 |
| 1 | 500 | 1466 | 22.90 | 24.50 | 25.05 | 26.25 | 170 | 160 | 157 | 150 |
| 1 | 400 | 1466 | 13.69 | 15.12 | 15.60 | 16.73 | 183 | 164 | 159 | 149 |
| 2 | 400 | 1159 | 17.32 | 18.58 | 19.06 | 20.12 | 114 | 106 | 104 | 99 |
| 3 | 400 | 921 | 22.00 | 23.05 | 23.50 | 24.30 | 72 | 69 | 68 | 66 |
| 3 | 300 | 921 | 11.40 | 12.40 | 12.73 | 13.51 | 77 | 71 | 69 | 65 |
| 4 | 300 | 730 | 14.78 | 15.70 | 15.93 | 16.68 | 47 | 45 | 44 | 43 |

†Allowable stress based on 14,000 lbs. per square inch. Sags and tensions calculated to give allowable stress under worst conditions specified above. Coeff. expansion—0.0000128. Modulus of elasticity—9,000,000.

## SAGS AND TENSIONS FOR ALUMINUM CABLES

(Worst Condition: 20° F., no Ice, 15 lb. Wind)

| Size (Copper Equivalent) | Span (Ft.) | †Allowable Stress Lb. | CONDITIONS WITHOUT WIND OR ICE — SAG IN FEET 20° | 70° | 100° | 130° | TENSION—LB. 20° | 70° | 100° | 130° |
|---|---|---|---|---|---|---|---|---|---|---|
| 350,000 | 600 | 6120 | 4.95 | 7.63 | 9.45 | 10.70 | 4550 | 3015 | 2430 | 2066 |
| 300,000 | 600 | 5250 | 5.13 | 7.95 | 9.78 | 11.60 | 3800 | 2500 | 2025 | 1710 |
| 250,000 | 600 | 4380 | 5.55 | 8.40 | 10.30 | 12.10 | 2940 | 1960 | 1603 | 1365 |
| 0000 | 600 | 3705 | 6.06 | 8.90 | 10.80 | 12.50 | 2310 | 1550 | 1290 | 1120 |
| 000 | 600 | 2932 | 6.93 | 10.00 | 11.76 | 13.43 | 1597 | 1115 | 945 | 827 |
| 00 | 500 | 2330 | 4.52 | 7.10 | 8.75 | 10.30 | 1340 | 860 | 699 | 593 |
| 0 | 500 | 1843 | 5.60 | 8.30 | 9.85 | 11.25 | 872 | 588 | 494 | 431 |
| 1 | 500 | 1466 | 6.98 | 9.20 | 10.65 | 12.05 | 595 | 419 | 362 | 320 |
| 2 | 400 | 1159 | 3.84 | 6.12 | 7.48 | 8.70 | 507 | 318 | 260 | 224 |
| 3 | 400 | 921 | 4.82 | 7.16 | 8.40 | 9.52 | 320 | 200 | 184 | 162 |
| 4 | 300 | 730 | 2.10 | 4.00 | 5.13 | 6.12 | 316 | 172 | 134 | 112 |

†Allowable stress based on 14,000 lbs. per sq. in. Sags and tensions calculated to give allowable stress under worst conditions specified above. Coeff. of expansion—0.0000128. Modulus of elasticity—9,000,000.

## EQUIVALENTS OF WIRES

Showing Approximately Equal Capacities in the Use of Conductors of Different Sizes

| Totals Capacity | Equalled by using the number of smaller conductors shown, or by the combinations. 2 | 3 | 4 | 5 | 6 | Combinations | |
|---|---|---|---|---|---|---|---|
| C. M. | | | | | | | |
| 1000000 | | | | ⅙ | ⅜ | | |
| 800000 | | | ⅙ | ⅜ | ⅜ | | |
| 600000 | | ⅙ | ⅜ | ⅜ | 1/6 | | |
| 500000 | | ⅜ | ⅜ | ⅙ | 1 | | |
| 400000 | ⅙ | ⅜ | ⅙ | 1 | 2 | | |
| 350000 | ⅜ | | 1 | 2 | | ⅙ & ⅜ | |
| 300000 | | 1/6 | 2 | | 3 | ⅜ & ⅜ | ⅙ & 1 |
| 250000 | ⅜ | 1 | | 3 | 4 | ⅜ & 1 | ⅙ & 4 |
| B. & S. Gauge | | | | | | | |
| 0000 | ⅙ | 2 | 3 | 4 | 5 | ⅜ & 1 | ⅜ & 3 |
| 000 | 1 | 3 | 4 | 5 | 6 | ⅙ & 2 | ⅜ & 5 |
| 00 | 2 | 4 | 5 | 6 | | 1 & 3 | ⅙ & 6 |
| 0 | 3 | 5 | 6 | | 8 | 2 & 4 | |
| 1 | 4 | 6 | | 8 | | 3 & 5 | |
| 2 | 5 | | 8 | | | 4 & 6 | |
| 3 | 6 | 8 | | 10 | | | |
| 4 | | | 10 | | | 6 & 8 | |
| 5 | 8 | 10 | | 12 | | | |
| 6 | | | 12 | | 14 | 8 & 10 | |
| 8 | | | 14 | | 16 | 10 & 12 | |
| 10 | | | 16 | | 18 | 12 & 14 | |

For the same rise in temperature a greater amount of current can be carried in two or more circuits, and the greater the number of circuits, the greater the amount of current that can be carried in any given cross-section, as shown by table of carrying capacities on Page 93.

## DECIMAL EQUIVALENTS

Of eighths, sixteenths, thirty-seconds and sixty-fourths of an inch.

| Fractions of an Inch | Decimals of an Inch | Fractions of an Inch | Decimals of an Inch | Fractions of an Inch | Decimals of an Inch | Fractions of an Inch | Decimals of an Inch |
|---|---|---|---|---|---|---|---|
| 1/64 = | .015625 | 17/64 = | .265625 | 33/64 = | .515625 | 49/64 = | .765625 |
| 1/32 = | .03125 | 9/32 = | .28125 | 17/32 = | .53125 | 25/32 = | .78125 |
| 3/64 = | .046875 | 19/64 = | .296875 | 35/64 = | .546875 | 51/64 = | .796875 |
| 1/16 = | .0625 | 5/16 = | .3125 | 9/16 = | .5625 | 13/16 = | .8125 |
| 5/64 = | .078125 | 21/64 = | .328125 | 37/64 = | .578125 | 53/64 = | .828125 |
| 3/32 = | .09375 | 11/32 = | .34375 | 19/32 = | .59375 | 27/32 = | .84375 |
| 7/64 = | .109375 | 23/64 = | .359375 | 39/64 = | .609375 | 55/64 = | .859375 |
| 1/8 = | .125 | 3/8 = | .375 | 5/8 = | .625 | 7/8 = | .875 |
| 9/64 = | .140625 | 25/64 = | .390625 | 41/64 = | .640625 | 57/64 = | .890625 |
| 5/32 = | .15625 | 13/32 = | .40625 | 21/32 = | .65625 | 29/32 = | .90625 |
| 11/64 = | .171875 | 27/64 = | .421895 | 43/64 = | .671875 | 59/64 = | .921875 |
| 3/16 = | .1875 | 7/16 = | .4375 | 11/16 = | .6875 | 15/16 = | .9375 |
| 13/64 = | .203125 | 29/64 = | .453125 | 45/64 = | .703125 | 61/64 = | .953125 |
| 7/32 = | .21875 | 15/32 = | .46875 | 23/32 = | .71875 | 31/32 = | .96875 |
| 15/64 = | .234375 | 31/64 = | .484375 | 47/64 = | .734375 | 63/64 = | .984375 |
| 1/4 = | .25 | 1/2 = | .5 | 3/4 = | .75 | | |

## FEET EXPRESSED IN DECIMAL PARTS OF A MILE

| | Units | Tens | Hundreds | Thousands |
|---|---|---|---|---|
| 1 | .000189 | .001893 | .01893 | .1893 |
| 2 | .000378 | .003787 | .03787 | .3787 |
| 3 | .000568 | .005681 | .05681 | .5681 |
| 4 | .000757 | .007574 | .07574 | .7574 |
| 5 | .000946 | .009468 | .09468 | .9468 |
| 6 | .001136 | .011362 | .11362 | |
| 7 | .001325 | .013255 | .13255 | |
| 8 | .001514 | .015148 | .15148 | |
| 9 | .001704 | .017042 | .17042 | |

## GENERAL EQUIVALENTS

CM = Circular mils.
SqM = Square mils.
1 CM = .7854 SqM.
1 SqM. = 1.2732 CM.
1 Sq in. = 1,000,000 SqM.

1 Sq in. = 1,273,200 CM.
1 Sq in. = area of a circle 1.128″ diam.
Area of circle 1″ diam. = 1,000,000 CM.
Area of circle 1″ diam. = 785,400 SqM.

## TABLE OF MULTIPLES

Diameter of a circle × 3.1416 = Circumference.
Radius of a circle × 6.283185 = Circumference.
Square of the radius of a circle × 3.1416 = Area.
Square of the diameter of a circle × 0.7854 = Area.
Square of the circumference of a circle × 0.07958 = Area.
Half the circumference of a circle × by half its diameter = Area.
Circumference of a circle × 0.159155 = Radius.
Square root of the area of a circle × 0.56419 = Radius.
Circumference of a circle × 0.31831 = Diameter.
Square root of the area of a circle × 1.12838 = Diameter.
Diameter of a circle × 0.86 = Side of inscribed equilateral triangle.
Diameter of a circle × 0.7071 = Side of an inscribed square.
Circumference of a circle × 0.225 = Side of an inscribed square.
Circumference of a circle × 0.282 = Side of an equal square.
Diameter of a circle × 0.8862 = Side of an equal square.
Base of a triangle × by ½ the altitude = Area.
Multiplying both diameters and .7854 together = Area of an eclipse.
Surface of a sphere × by 1/6 of its diameter = Solidity.
Circumference of a sphere × by its diameter = Surface.
Square of the diameter of a sphere × 3.1416 = Surface.
Square of the circumference of a sphere × 0.3183 = Surface.
Cube of the diameter of a sphere × 0.5236 = Solidity.
Cube of the radius of a sphere × 4.1888 = Solidity.
Cube of the circumference of a sphere × 0.016887 = Solidity.
Square root of the surface of a sphere × 0.56419 = Diameter.
Square root of the surface of a sphere × 1.772454 = Circumference.
Cube root of the solidity of a sphere × 1.2407 = Diameter.
Cube root of the solidity of a sphere × 3.8978 = Circumference.
Radius of a sphere × 1.1547 = Side of inscribed cube.
Square root of (1/3 of the square of) the diameter of a sphere = Side of inscribed cube.
Area of its base × by 1/3 of its altitude = Solidity of a cone or pyramid, whether round, square or triangular.
Area of one of its sides × 6 = the surface of a cube.
Altitude of trapezoid × ½ the sum of its parallel sides = Area.

## METRIC SYSTEM OF WEIGHTS AND MEASURES

### LINEAR MEASURES

| | | | |
|---|---|---|---|
| 10 Millimeters | (mm) | = 1 Centimeter | = .3937 Inch. |
| 10 Centimeters | (cm) | = 1 Decimeter | = .3281 Feet. |
| 10 Decimeters | (dm) | = 1 Meter | = 1.0936 Yards. |
| 10 Meters | (m) | = 1 Dekameter | = 1.988 Rods. |
| 10 Dekameters | (Dm) | = 1 Hectometer | = .497 Furlongs. |
| 10 Hectometers | (Hm) | = 1 Kilometer | = .621 Miles. |
| 10 Kilometers | (Km) | = 1 Myriameter | = 6.21 Miles. |

### SQUARE MEASURES

| | | | |
|---|---|---|---|
| 100 Sq. mms. | ($mm^2$) | = 1 Sq. Centimeter | = .155 Sq. In. |
| 100 Sq. cms. | ($cm^2$) | = 1 Sq. Decimeter | = .10764 Sq. Ft. |
| 100 Sq. dms. | ($dm^2$) | = 1 Sq. Meter ($m^2$) | = 1.196 Sq. Yds. |

### LAND MEASURES

| | | |
|---|---|---|
| 10000 Sq. Meters | = 1 Hectare | = 2.471 Acres. |
| 100 Hectares | = 1 Sq. Kilometer | = .3861 Sq. Miles. |

### CUBIC MEASURES

| | | |
|---|---|---|
| 1000 Cu. mms. ($mm^3$) | = 1 Cu. cm | = .061 Cu. In. |
| 1000 Cu. cms. ($cm^3$ or cc) | = 1 Cu. dm | = .0353 Cu. Ft. |
| 1000 Cu. dms. ($dm^3$) | = 1 Cu. M. ($m^3$) | = 1.308 Cu. Yd. |

### DRY MEASURES

| | | |
|---|---|---|
| 10 Millisteres | = 1 Centistere | = 1.135 U. S. Peck. |
| 10 Centisteres | = 1 Decistere | = 2.83783 U. S. Bush. |
| 10 Decisteres | = 1 Stere | = 1 Cubic Meter. |

### LIQUID MEASURES

| | | |
|---|---|---|
| 10 Milliliters | = 1 Centiliter | = .084537 U. S. Gills. |
| 10 Centiliters | = 1 Deciliter | = .21134 U. S. Pints. |
| 10 Deciliters | = 1 Liter | = 1.05671 U. S. Quarts. |

### MEASURES OF WEIGHT

| | | | |
|---|---|---|---|
| 10 Milligrams | (mg) | = 1 Centigram | = .15432 Grains. |
| 10 Centigrams | (cg) | = 1 Decigram | = 1.5432 Grains. |
| 10 Decigrams | (dg) | = 1 Gram | = .56437 Drams. |
| 10 Grams | (g) | = 1 Dekagram | = .35273 Ounces. |
| 10 Dekagrams | (Dg) | = 1 Hectogram | = 3.5273 Ounces. |
| 10 Hectograms | (Hg) | = 1 Kilogram | = 2.2046 Lbs. Avoir. |
| 1000 Kilograms | (Kg) | = 1 Metric Ton | = 2204.6 Lbs. Avoir. |

## METRIC CONVERSION FACTORS

Equivalents of metric measures not given in the preceding tables, are readily found by the following factors:

Millimeters ÷ 25.4 = Inches.
Meters x 39.37 = Inches.
Meters x 3.281 = Feet.
Meters per sec. x 2.237 = Miles per hour.
Meters per sec. x 53.686 = Miles per day.
Kilometers x .62137 = Miles.
Kilometers x 3280.83 = Feet.
Kilometers per hour ÷ 1.097 = Feet per second.
Kilometers per hour ÷ 96.58 = Miles per minute.
Square Millimeters ÷ 645.16 = Square Inches.
Square Millimeters x 1973 = Circular Mils.
Square Meters x 10.764 = Square Feet.
Square Kilometers x 247.1 = Acres.
Cubic Centimeters ÷ 16.387 = Cubic Inches.
Cubic Centimeters ÷ 29.574 = Fluid Ounces.
Cubic Meters x 35.315 = Cubic Feet.
Cubic Meters ÷ .76456 = Cubic Yards.
Cubic Meters x 264.17 = Gallons.
Liters x 61.0234 = Cubic Inches.
Liters x 33.84 = Fluid Ounces.
Liters ÷ 3.785 = Gallons.
Liters per sec. x 127.132 = Cubic Feet per hour.
Hectoliters x 3.5314 = Cubic Feet.
Hectoliters x 26.42 = Gallons.
Grams x 15.432 = Grains.
Grams ÷ 29.57 = Fluid Ounces.
Grams ÷ 28.35 = Ounces Avoirdupois.
Grams per meter = Kilograms per Kilometer.
Grams per meter ÷ 1.488 = Lbs. per 1000 feet.
Grams per meter x 3.548 = Lbs. per mile.
Grams per cu. cm. ÷ 27.68 = Lbs. per cubic inch.
Kilograms x 2.2046 = Pounds.
Kilograms ÷ 907.2 = Short Tons (2000 lbs.).
Kilograms ÷ 1016.2 = Long Tons (2240 lbs.).
Kilograms per sq. cm. x 14.2234 = Lbs. per sq. in.
Kilograms per meter x .672 = Pounds per foot.
Kilograms per cu. Meter x .06243 = Lbs. per cu. ft.
Kilograms per Cheval x 2.235 = Lbs. per Horse Power.
Kilogrammeters x 7.233 = Foot Pounds.
Watts ÷ 746 = Horse Power.
Watts ÷ .7373 = Foot Pounds per second.
Kilowatts x 1.34 = Horse Power.
Calorie x 3.968 = B. T. U.
Cheval vapeur x .9863 = Horse Power.
(Centigrade x 1.80) + 32 = Degrees Fahrenheit.

## THE METRIC SYSTEM

### Weights

| Metric Denominations and Values — Name. | No. Grams. | Equivalents in Denominations in use. Weight of what quantity of water at maximum density. |
|---|---|---|
| Millier or tonneau | 1,000,000 | 1 cubic meter. |
| Quintal | 100,000 | 1 hectoliter. |
| Myriagram | 10,000 | 10 liters. |
| Kilogram or Kilo | 1,000 | 1 liter. |
| Hectogram | 100 | 1 deciliter. |
| Dekagram | 10 | 10 cu. centimeters. |
| Gram | 1 | 1 cu. centimeter. |
| Decigram | .1 | 1 cu. centimeter. |
| Centigram | .01 | 10 cu. millimeters. |
| Milligram | .001 | 1 cu. millimeter. |

| Name. | No. Grams. | Avoirdupois Weight. |
|---|---|---|
| Millier or tonneau | 1,000,000 | 2,204.6 pounds. |
| Quintal | 100,000 | 220.46 pounds. |
| Myriagram | 10,000 | 22.046 pounds. |
| Kilogram or Kilo | 1,000 | 2.2046 pounds. |
| Hectogram | 100 | 3.5274 ounces. |
| Dekagram | 10 | 0.3527 ounce. |
| Gram | 1 | 15.432 grains. |
| Decigram | .1 | 1.5432 grains. |
| Centigram | .01 | 0.1543 grain. |
| Milligram | .001 | 0.0154 grain. |

### Measures of Length

| | | |
|---|---|---|
| Myriameter | 10,000 meters | 6.2137 miles. |
| Kilometer | 1,000 meters | 0.62137 m. or 3,280 ft. 10 in. |
| Hectometer | 100 meters | 328 ft. and 1 inch. |
| Dekameter | 10 meters | 393.7 inches. |
| Meter | 1 meter | 39.37 inches. |
| Decimeter | .1 of a meter | 3.937 inches. |
| Centimeter | .01 of a meter | 0.3937 inch. |
| Millimeter | .001 of a meter | 0.0394 inch. |

### Measures of Surface

| | | |
|---|---|---|
| Hectare | 10,000 sq. meters | 2.471 acres. |
| Are | 100 sq. meters | 119.6 sq. yards. |
| Centare | 1 sq. meter | 1,550 square inches. |

### Measures of Capacity

| Name. | No. Liters. | Cubic Measure. | Dry Measure |
|---|---|---|---|
| Kiloliter | 1,000 | 1 cubic meter | 1.308 cu. yds. |
| Hectoliter | 100 | .1 cubic meter | 2 bu. 3.35 pks. |
| Decaliter | 10 | 10 cu. decimeters | 9.08 quarts. |
| Liter | 1 | 1 cu. decimeter | 0.908 quart. |
| Deciliter | .1 | .1 cu. decimeter | 6.1022 cu. ins. |
| Centiliter | .01 | 10 cu. centimeters | 0.6102 cu. in. |
| Milliliter | .001 | 1 cu. centimeter | 0.061 cu. in. |

| Name. | No. Liters. | Cubic Measure. | Wine Measure. |
|---|---|---|---|
| Kiloliter | 1,000 | 1 cubic meter | 264.17 gals. |
| Hectoliter | 100 | .1 cubic meter | 26.417 gals. |
| Decaliter | 10 | 10 cu. decimeters | 2.6417 gals. |
| Liter | 1 | 1 cu. decimeter | 1.0567 quarts. |
| Deciliter | .1 | .1 cu. decimeter | 0.845 gill. |
| Centiliter | .01 | 10 cu. centimeters | 0.388 fluid oz. |
| Milliliter | .001 | 1 cu. centimeter | 0.27 fluid oz. |

### Unit. Equivalent Value In Other Units

**1 H. P. =**
- 746 watts.
- .746 K. W.
- 33,000 ft.-lbs. per minute.
- 550 ft.-lbs. per second.
- 2,545 heat-units per hour.
- 42.4 heat-units per minute.
- .707 heat-unit per second.
- .175 lb. carbon oxidized per hour.
- 2.64 lbs. water evaporated per hour from and at 212° F.

**1 H. P. Hour =**
- 746 K. W. hours.
- 1,980,000 ft.-lbs.
- 2,545 heat-units.
- 273,740 K. G. M.
- .175 lb. carbon oxidized with perfect efficiency.
- 2.64 lbs. water evaporated from and at 212° F.
- 17.0 lbs. water raised from 62° to 212° F.

### Unit. Equivalent Value In Other Units

**1 Kilowatt =**
- 1,000 watts.
- 1.34 H. P.
- 2,654,200 ft.-lbs. per hour.
- 44,240 ft.-lbs. per minute.
- 737.3 ft.-lbs. per second.
- 3,412 heat-units per hour.
- 56.9 heat-units per minute.
- .948 heat-unit per second.
- .2275 lb. carbon oxidized per hour.
- 3.53 lbs. water evaporated per hour from and at 212° F.

**1 Watt per sq. in. =**
- 8.19 heat units per sq. ft. per minute.
- 6371 ft.-lbs. per sq. ft. per minute.
- .193 H. P. per sq. ft.

**1 Kilogram Meter =**
- 7.233 ft.-lbs.
- .00000365 H. P. hour.
- .00000272 K. W. hour.
- .0093 heat-units.

**1 lb. Water Evaporated from and at 212°F. =**
- .283 K. W. hour.
- .379 H. P. hour.
- 965.7 heat-units.
- 103,900 k. g. m.
- 1,019,000 joules.
- 751,300 ft.-lbs.
- .0664 lb. of carbon oxidized.

**1 Heat-unit =**
- 1,055 watt seconds.
- 778 ft.-lbs.
- 107.6 kilogram meters.
- .000293 K. W. hour.
- .000393 H. P. hour.
- .0000688 lb. carbon oxidized.
- .001036 lb. water evaporated from and at 212° F.

**1 Heat-unit per sq. ft. per min. =**
- .122 watts per sq. in.
- .0176 K. W. per sq. ft.
- .0236 H. P. per sq. ft.

**1 Watt =**
- 1 joule per second.
- .00134 H. P.
- 3,412 heat-units per hour.
- .7373 ft.-lb. per second.
- .0035 lb. water evaporated per hour.
- 44.24 ft.-lbs. per minute.

**1 K. W. Hour =**
- 1,000 watt hours.
- 1.34 H. P. hours.
- 2,654,200 ft.-lbs.
- 3,600,000 joules.
- 3,412 heat-units.
- 367,000 kilogram meters.
- .235 lb. carbon oxidized with perfect efficiency.
- 3.53 lbs. water evaporated from and at 212° F.
- 22.75 lbs. of water raised from 62° to 212° F.

**1 Joule =**
- 1 watt second.
- .000000278 K. W. hour.
- .102 k. g. m.
- .0009477 heat-units.
- .7373 ft.-lb.

**1 ft.-lb. =**
- 1.356 joules.
- .1383 k. g. m.
- .000000377 K. W. hours.
- .001285 heat-units.
- .0000005 H. P. hour.

**1 lb. Carbon Oxidized with Perfect Efficiency =**
- 14,544 heat-units.
- 1.11 lb. anthracite coal ox.
- 2.5 lbs. dry wood oxidized.
- 21 cu. ft. illuminating gas.
- 4.26 K. W. hours.
- 5.71 H. P. hours.
- 11,315,000 ft.-lbs.
- 15 lbs. of water evaporated from and at 212° F.

## METRIC CONVERSION TABLES

### Properties of Copper Wire Expressed in the Metric System

| Size B. & S. Gauge | Diameter in Millimeters | Area in Square Millimeters | Weight per Kilometer, in Kilograms | Resistance per Kilometer Int'n'l Ohms. |
|---|---|---|---|---|
| 0000 | 11.684 | 107.20 | 953 2 | .1608 |
| 000 | 10.404 | 85.03 | 755.9 | .2028 |
| 00 | 9.266 | 67.43 | 599.5 | .2557 |
| 0 | 8.252 | 53.48 | 475.4 | .3224 |
| 1 | 7.348 | 42.41 | 377.0 | .4066 |
| 2 | 6.543 | 33.63 | 299.0 | .5127 |
| 3 | 5.827 | 26.67 | 237.1 | .6465 |
| 4 | 5.189 | 21.15 | 188.0 | .8152 |
| 5 | 4.620 | 16.77 | 149.1 | 1.028 |
| 6 | 4.115 | 13.30 | 118.2 | 1.296 |
| 7 | 3.665 | 10.55 | 93.8 | 1.634 |
| 8 | 3.264 | 8.366 | 74.4 | 2.061 |
| 9 | 2.906 | 6.634 | 59.0 | 2.599 |
| 10 | 2.588 | 5.261 | 46.8 | 3.277 |
| 11 | 2.304 | 4.172 | 37.1 | 4.132 |
| 12 | 2.052 | 3.309 | 29.4 | 5.211 |
| 13 | 1.829 | 2.624 | 23.3 | 6.571 |
| 14 | 1.628 | 2.081 | 18.5 | 8.285 |
| 15 | 1.450 | 1.650 | 14.7 | 10.45 |
| 16 | 1.290 | 1.309 | 11.6 | 13.17 |
| 17 | 1.151 | 1.038 | 9.23 | 16.61 |
| 18 | 1.024 | .8231 | 7.32 | 20.95 |
| 19 | .9119 | .6527 | 5.80 | 26.42 |
| 20 | .8128 | .5176 | 4.60 | 33.31 |
| 21 | .7229 | .4105 | 3.65 | 42.00 |
| 22 | .6426 | .3255 | 2.89 | 52.96 |
| 23 | .5740 | .2582 | 2.30 | 66.79 |
| 24 | .5105 | .2047 | 1.82 | 84.21 |
| 25 | .4546 | .1624 | 1.44 | 106.2 |
| 26 | .4049 | .1288 | 1.15 | 133.9 |
| 27 | .3605 | .1021 | .908 | 168.9 |
| 28 | .3211 | .0810 | .720 | 212.9 |
| 29 | .2859 | .0642 | .571 | 268.5 |
| 30 | .2540 | .0509 | .453 | 338.6 |
| 31 | .2268 | .0404 | .359 | 426.9 |
| 32 | .2019 | .0320 | .285 | 538.3 |
| 33 | .1798 | .0254 | .226 | 678.8 |
| 34 | .1601 | .0201 | .179 | 856.0 |
| 35 | .1425 | .0160 | .142 | 1079. |
| 36 | .1270 | .0127 | .113 | 1361. |

### Fractions and Their Equivalents in Decimals of an Inch and in Millimeters

| Frac'ns | | Dcmls | mms. | Frac'ns | | Dcmls | mms. |
|---|---|---|---|---|---|---|---|
| | 1/64 | .0156 | .397 | | 33/64 | .5156 | 13.097 |
| 1/32 | | .0313 | .794 | 17/32 | | .5313 | 13.494 |
| | 3/64 | .0469 | 1.191 | | 35/64 | .5469 | 13.891 |
| 1/16 | | .0625 | 1.588 | 9/16 | | .5625 | 14.288 |
| | 5/64 | .0781 | 1.984 | | 37/64 | .5781 | 14.684 |
| 3/32 | | .0938 | 2.381 | 19/32 | | .5938 | 15.081 |
| | 7/64 | .1094 | 2.778 | | 39/64 | .6094 | 15.478 |
| 1/8 | | .1250 | 3.175 | 5/8 | | .6250 | 15.875 |
| | 9/64 | .1406 | 3.572 | | 41/64 | .6406 | 16.272 |
| 5/32 | | .1563 | 3.969 | 21/32 | | .6563 | 16.669 |
| | 11/64 | .1719 | 4.366 | | 43/64 | .6719 | 17.066 |
| 3/16 | | .1875 | 4.763 | 11/16 | | .6875 | 17.463 |
| | 13/64 | .2031 | 5.159 | | 45/64 | .7031 | 17.859 |
| 7/32 | | .2188 | 5.556 | 23/32 | | .7188 | 18.256 |
| | 15/64 | .2344 | 5.953 | | 47/64 | .7344 | 18.653 |
| 1/4 | | .2500 | 6.350 | 3/4 | | .7500 | 19.050 |
| | 17/64 | .2656 | 6.747 | | 49/64 | .7656 | 19.447 |
| 9/32 | | .2813 | 7.144 | 25/32 | | .7813 | 19.844 |
| | 19/64 | .2969 | 7.541 | | 51/64 | .7969 | 20.241 |
| 5/16 | | .3125 | 7.938 | 13/16 | | .8125 | 20.638 |
| | 21/64 | .3281 | 8.334 | | 53/64 | .8281 | 21.034 |
| 11/32 | | .3438 | 8.731 | 27/32 | | .8438 | 21.431 |
| | 23/64 | .3594 | 9.128 | | 55/64 | .8594 | 21.828 |
| 3/8 | | .3750 | 9.525 | 7/8 | | .8750 | 22.225 |
| | 25/64 | .3906 | 9.922 | | 57/64 | .8906 | 22.622 |
| 13/32 | | .4063 | 10.319 | 29/32 | | .9063 | 23.019 |
| | 27/64 | .4219 | 10.716 | | 59/64 | .9219 | 23.416 |
| 7/16 | | .4375 | 11.113 | 15/16 | | .9375 | 23.813 |
| | 29/64 | .4531 | 11.509 | | 61/64 | .9531 | 24.209 |
| 15/32 | | .4688 | 11.906 | 31/32 | | .9688 | 24.606 |
| | 31/64 | .4844 | 12.303 | | 63/64 | .9844 | 25.003 |
| 1/2 | | .5000 | 12.700 | 1 | | 1.0000 | 25.400 |

## METRIC CONVERSION TABLES

### Millimeters to Mils

| mms. | Mils | mms. | Mils | mms. | Mils | mms. | Mils |
|---|---|---|---|---|---|---|---|
| 1 | 39.37 | 26 | 1 023.60 | 51 | 2 007.87 | 76 | 2 992.12 |
| 2 | 78.74 | 27 | 1 063.00 | 52 | 2 047.24 | 77 | 3 031.49 |
| 3 | 118.11 | 28 | 1 102.40 | 53 | 2 086.61 | 78 | 3 070.86 |
| 4 | 157.48 | 29 | 1 141.70 | 54 | 2 125 98 | 79 | 3 110.23 |
| 5 | 196.85 | 30 | 1 181.10 | 55 | 2 165.35 | 80 | 3 149.60 |
| 6 | 236.22 | 31 | 1 220.50 | 56 | 2 204.72 | 81 | 3 188.97 |
| 7 | 275.59 | 32 | 1 259.80 | 57 | 2 244.09 | 82 | 3 228.34 |
| 8 | 314.96 | 33 | 1 299.20 | 58 | 2 283.46 | 83 | 3 267.71 |
| 9 | 354.33 | 34 | 1 338.60 | 59 | 2 322.83 | 84 | 3 307.08 |
| 10 | 393.70 | 35 | 1 378.00 | 60 | 2 362.20 | 85 | 3 346.45 |
| 11 | 433.07 | 36 | 1 417.30 | 61 | 2 401.57 | 86 | 3 385.82 |
| 12 | 472.44 | 37 | 1 456.70 | 62 | 2 440.94 | 87 | 3 425.19 |
| 13 | 511.81 | 38 | 1 496.10 | 63 | 2 480.31 | 88 | 3 464.56 |
| 14 | 551.18 | 39 | 1 535.40 | 64 | 2 519.68 | 89 | 3 503.93 |
| 15 | 590.55 | 40 | 1 574.80 | 65 | 2 559.05 | 90 | 3 543.30 |
| 16 | 629.92 | 41 | 1 614.17 | 66 | 2 598.42 | 91 | 3 582.67 |
| 17 | 669.29 | 42 | 1 653.54 | 67 | 2 637.79 | 92 | 3 622.04 |
| 18 | 708.66 | 43 | 1 692.91 | 68 | 2 677.16 | 93 | 3 661.41 |
| 19 | 748.03 | 44 | 1 732.28 | 69 | 2 716.53 | 94 | 3 700.78 |
| 20 | 787.40 | 45 | 1 771.65 | 70 | 2 755.90 | 95 | 3 740.15 |
| 21 | 826.77 | 46 | 1 811.02 | 71 | 2 795.27 | 96 | 3 779.52 |
| 22 | 866.14 | 47 | 1 850.39 | 72 | 2 834.64 | 97 | 3 818.89 |
| 23 | 905.51 | 48 | 1 889.76 | 73 | 2 874.01 | 98 | 3 858.26 |
| 24 | 944.88 | 49 | 1 929.13 | 74 | 2 913.38 | 99 | 3 897.63 |
| 25 | 984.25 | 50 | 1 968.50 | 75 | 2 952.75 | 100 | 3 937.00 |

### Mils to Millimeters

| Mils | mms. | Mils | mms. | Mils | mms. | Mils | mms. |
|---|---|---|---|---|---|---|---|
| 1 | .025 4 | 26 | .660 4 | 51 | 1.295 4 | 76 | 1.930 4 |
| 2 | .050 8 | 27 | .685 8 | 52 | 1.320 8 | 77 | 1.955 8 |
| 3 | .076 2 | 28 | .711 2 | 53 | 1.346 2 | 78 | 1.981 2 |
| 4 | .101 6 | 29 | .736 6 | 54 | 1.371 6 | 79 | 2.006 6 |
| 5 | .127 0 | 30 | .762 0 | 55 | 1.397 0 | 80 | 2.032 0 |
| 6 | .152 4 | 31 | .787 4 | 56 | 1.422 4 | 81 | 2.057 4 |
| 7 | .177 8 | 32 | .812 8 | 57 | 1.447 8 | 82 | 2.082 8 |
| 8 | .203 2 | 33 | .838 2 | 58 | 1.473 2 | 83 | 2.108 2 |
| 9 | .228 6 | 34 | .863 6 | 59 | 1.498 6 | 84 | 2.133 6 |
| 10 | .254 0 | 35 | .889 0 | 60 | 1.524 0 | 85 | 2.159 0 |
| 11 | .279 4 | 36 | .914 4 | 61 | 1.549 4 | 86 | 2.184 4 |
| 12 | .304 8 | 37 | .939 8 | 62 | 1.574 8 | 87 | 2.209 8 |
| 13 | .330 2 | 38 | .965 2 | 63 | 1.600 2 | 88 | 2.235 2 |
| 14 | .355 6 | 39 | .990 6 | 64 | 1.625 6 | 89 | 2.260 6 |
| 15 | .381 0 | 40 | 1.016 0 | 65 | 1.651 0 | 90 | 2.286 0 |
| 16 | .406 4 | 41 | 1.041 4 | 66 | 1.676 4 | 91 | 2.311 4 |
| 17 | .431 8 | 42 | 1.066 8 | 67 | 1.701 8 | 92 | 2.336 8 |
| 18 | .457 2 | 43 | 1.092 2 | 68 | 1.727 2 | 93 | 2.362 2 |
| 19 | .482 6 | 44 | 1.117 6 | 69 | 1.752 6 | 94 | 2.387 6 |
| 20 | .508 0 | 45 | 1.143 0 | 70 | 1.778 0 | 95 | 2.413 0 |
| 21 | .533 4 | 46 | 1.168 4 | 71 | 1.803 4 | 96 | 2.438 4 |
| 22 | .558 8 | 47 | 1.193 8 | 72 | 1.828 8 | 97 | 2.463 8 |
| 23 | .584 2 | 48 | 1.219 2 | 73 | 1.854 2 | 98 | 2.489 2 |
| 24 | .609 6 | 49 | 1.244 6 | 74 | 1.879 6 | 99 | 2.514 6 |
| 25 | .635 0 | 50 | 1.270 0 | 75 | 1.905 0 | 100 | 2.540 0 |

## SQUARE MILLIMETERS AREA TO INCHES DIAMETER

| mm² | Inches | mm² | Inches | mm² | Inches | mm² | Inches |
|---|---|---|---|---|---|---|---|
| 1 | .044 | 26 | .227 | 51 | .317 | 76 | .387 |
| 2 | .063 | 27 | .231 | 52 | .320 | 77 | .390 |
| 3 | .077 | 28 | .235 | 53 | .323 | 78 | .392 |
| 4 | .089 | 29 | .239 | 54 | .326 | 79 | .395 |
| 5 | .099 | 30 | .243 | 55 | .329 | 80 | .397 |
| 6 | .109 | 31 | .247 | 56 | .332 | 81 | .400 |
| 7 | .118 | 32 | .251 | 57 | .335 | 82 | .402 |
| 8 | .126 | 33 | .255 | 58 | .338 | 83 | .405 |
| 9 | .133 | 34 | .259 | 59 | .341 | 84 | .407 |
| 10 | .140 | 35 | .263 | 60 | .344 | 85 | .410 |
| 11 | .147 | 36 | .267 | 61 | .347 | 86 | .412 |
| 12 | .154 | 37 | .270 | 62 | .350 | 87 | .414 |
| 13 | .160 | 38 | .274 | 63 | .353 | 88 | .417 |
| 14 | .166 | 39 | .277 | 64 | .355 | 89 | .419 |
| 15 | .172 | 40 | .281 | 65 | .358 | 90 | .421 |
| 16 | .178 | 41 | .284 | 66 | .361 | 91 | .424 |
| 17 | .183 | 42 | .288 | 67 | .364 | 92 | .426 |
| 18 | .189 | 43 | .291 | 68 | .366 | 93 | .428 |
| 19 | .193 | 44 | .295 | 69 | .369 | 94 | .431 |
| 20 | .199 | 45 | .298 | 70 | .372 | 95 | .433 |
| 21 | .204 | 46 | .301 | 71 | .374 | 96 | .435 |
| 22 | .208 | 47 | .305 | 72 | .377 | 97 | .438 |
| 23 | .213 | 48 | .308 | 73 | .380 | 98 | .440 |
| 24 | .218 | 49 | .311 | 74 | .382 | 99 | .442 |
| 25 | .222 | 50 | .314 | 75 | .385 | 100 | .444 |

# PULLEY AND GEAR TABLES

For single reduction or increase of speed by means of belting where the speed at which each shaft should run is known, and one pulley is in place:

Multiply the diameter of the pulley which you have by the number of revolutions per minute that its shaft makes; divide this product by the speed in R. P. M. at which the second shaft should run. The result is the diameter of pulley to use.

Where both shafts with pulleys are in operation and the speed of one is known:

Multiply the speed of shaft by diameter of its pulley and divide this product by diameter of pulley on the other shaft. The result is the speed of the second shaft.

Where a countershaft is used, to obtain size of main driving or driven pulley, or speed of main driving or driven shaft, it is necessary to calculate between the known end of the transmission and the countershaft, then repeat this calculation between the countershaft and the unknown end.

A set of gears of the same pitch transmit speeds in proportion to the number of teeth they contain. Count the number of teeth in the gear wheel and use this quantity instead of the diameter of pulley mentioned, to obtain number of teeth cut in unknown gear, or speed of second shaft.

### RULE FOR FINDING SIZE OF PULLEYS

$$d = \frac{D \times S}{S'} \qquad D = \frac{d \times S'}{S}$$

d = diameter of driven pulley.
D = diameter of driving pulley.
S = number of revolutions per minute of driving pulley.
S′ = number of revolutions per minute of driven pulley.

### GEAR TABLE—DIAMETRAL PITCH. (Nuttall)

Diametral Pitch is the Number of Teeth to Each Inch of the Pitch Diameter

| To Get | Having | Rule |
|---|---|---|
| The Diametral Pitch | The Circular Pitch | Divide 3.1416 by the Circular Pitch |
| The Diametral Pitch | The Pitch Diameter and the Number of Teeth | Divide Number of Teeth by Pitch Diameter |
| The Diametral Pitch | The Outside Diameter and the Number of Teeth | Divide Number of Teeth plus 2 by Outside Diameter |
| Pitch Diameter | The Number of Teeth and the Diametral Pitch | Divide Number of Teeth by the Diametral Pitch |
| Pitch Diameter | The Number of Teeth and Outside Diameter | Divide the product of Outside Diam. and No. of Teeth by No. of Teeth plus 2 |
| Pitch Diameter | The Outside Diameter and the Diametral Pitch | Subtract from Outside Diam. the quotient of 2 divided by the Diam't'l Pitch |
| Pitch Diameter | Addendum and the Number of Teeth | Multiply Addendum by the Number of Teeth |
| Outside Diameter | The Number of Teeth and the Diametral Pitch | Divide Number of Teeth plus 2 by the Diametral Pitch |
| Outside Diameter | The Pitch Diameter and the Diametral Pitch | Add to the Pitch Diameter the quotient of 2 divided by the Diametral Pitch |
| Outside Diameter | The Pitch Diameter and the Number of Teeth | Divide Product of Number of Teeth plus 2 and Pitch Diameter by the Number of Teeth |
| Outside Diameter | The Number of Teeth and Addendum | Multiply the Number of Teeth plus 2 by Addendum |
| Number of Teeth | The Pitch Diameter and the Diametral Pitch | Multiply Pitch Diameter by the Diametral Pitch |
| Number of Teeth | The Outside Diameter and the Diametral Pitch | Multiply Outside Diameter by the Diametral Pitch and subtract 2 |
| Thickness of Tooth | The Diametral Pitch | Divide 1.5708 by the Diametral Pitch |
| Addendum | The Diametral Pitch | Divide 1 by the Diametral Pitch, or $s = \frac{D'}{N}$ |
| Root | The Diametral Pitch | Divide 1.157 by the Diametral Pitch |
| Working Depth | The Diametral Pitch | Divide 2 by the Diametral Pitch |
| Whole Depth | The Diametral Pitch | Divide 2.157 by the Diametral Pitch |
| Clearance | The Diametral Pitch | Divide .157 by the Diametral Pitch |
| Clearance | Thickness of Tooth | Divide Thickness of Tooth at pitch line by 10 |

# STORAGE BATTERY DATA

Storage batteries are made for either stationary or portable service. Both positive and negative plates are of pure lead, so that local action is reduced to a minimum. This feature results in high efficiency, long life and ability to hold charge through a long period of open circuit.

The mechanical design of the plate is such that the active material is in a thin layer supported by a conductor, and accessible to the current and electrolyte. Provision is made within the positive plate itself to accommodate any distortion of the active portions.

The approximate discharge voltage of a cell is two volts. Therefore, the battery discharge voltage is the number of cells in series multiplied by two. The ampere hour capacity, the rate of discharge and the rate of charge of a battery are determined by the size and number of plates in a cell.

The voltage required to charge a cell varies from 2.1 volts at the beginning to as high as 2.8 volts at the end, the cell charging at a constant current, usually the 8-hour discharge rate. The charging current is usually controlled by a rheostat in series with the battery, booster generator, or generator field control.

The maximum line voltage to be provided for charging a given number of cells in series is the number of cells multiplied by 2.8. The charging current will depend upon the size of the cell.

When a cell discharges, the electrolyte (sulphuric acid solution) forms the active material into lead sulphite and becomes weaker in acid with an increasing per cent. of water, and conversely, on charge the sulphate is changed back to acid. A definite amount of sulphate is formed for each ampere-hour discharge, therefore the density or specific gravity of the electrolyte changes a given amount.

This change in specific gravity of the electrolyte is proportional to the ampere-hours output and is practically independent of the rate of discharge. A very convenient and accurate method of charging is available by using a hydrometer to measure the change in specific gravity between the conditions of full charge and full discharge, and then charging until the original specific gravity of the electrolyte is reached.

The energy remaining in a cell at any time during a discharge can be found by noting the change in specific gravity of the electrolyte from the value at the beginning of the discharge and comparing it with the total range for the given discharge rate.

The range in density of specific gravity of the electrolyte between full charge and discharge, at the 8-hour rate, is approximately from 1,200 to 1,160 for a standard cell in a glass jar, the temperature being 70° F. The range will be approximately from 1,200 to 1,180 for a discharge at the one-hour rate.

The exact change in gravity should be determined for each particular size of cell, as it varies with the size of jar and the number of plates.

The normal ampere-hour capacity of a cell is based upon the 8-hour rate of discharge and is arbitrarily taken at 100%. When taken at other rates, the ampere-hour capacity varies.

The available ampere-hour capacity varies with the temperature and rate of discharge. For a limited range of temperature at the 8-hour rate of discharge, the capacity varies approximately one-half of one per cent. for each degree Fahrenheit change in temperature above or below 70° F. An increase in temperature will raise the capacity and a reduction will lower it. The lower the rate of discharge, the less will be the variation due to temperature.

Storage batteries may be used to great advantage in maintaining a constant load on a generating system when the load factor is poor. A sample of such regulation is shown in reproduction from recording ammeter records of a battery and regulator maintaining a constant load upon the generating system with an exceedingly variable external load.

When it is desired to maintain a constant alternating current load, the same degree of regulation may be obtained as in direct current work, by connecting the battery across the direct current side of a boosted rotary converter controlled by the regulator.

### RULES FOR CARE OF BATTERY

1. Do not over discharge battery.
2. Use only distilled water and chemically pure acid.
3. Never adjust specific gravity of solution by adding acid until cause of the change in specific gravity is found and remedied.
4. Maintain the solution at standard level and at standard strength by testing and adjusting once in two weeks.
5. Keep the cells clean, all wood work well painted, and metal work protected by acid-proof varnish or vaseline.

# LAMP DATA

## OPERATING PRINCIPLES OF MAZDA B LAMPS

Until about 1913 the filaments of all commercial electric incandescent lamps were operated in bulbs from which practically all air and gases had been removed. The evacuation of the bulb accomplishes two purposes: First, it prevents the filament being consumed by the oxygen of the air; second, it prevents the loss of heat from the filament by convection. As the temperature of the filament of a lamp is raised the light given out increases much more rapidly than the energy consumed but, on the other hand, the rate of evaporation of the filament is increased. It is, therefore, desirable from the standpoint of efficient transformation of electric energy into light to operate the filament at the highest temperature that it can withstand without causing it to evaporate at any excessively rapid rate. The rate of evaporation of a given filament at a certain temperature, and consequently the life of the lamp, depends upon the ability of the filament to withstand evaporation. There is a great difference in this respect in the various materials which may be used as filaments, and this is one reason why it is possible for the metallic-filament lamps to produce so much more light for a given consumption of energy than the older carbon-filament lamps, and give at the same time a more satisfactory life performance. It would be possible to operate the ordinary carbon lamps at an efficiency as high as that of the metallic-filament lamps but the life would be so short as to preclude their use commercially at such an efficiency.

## OPERATING PRINCIPLES OF MAZDA C LAMPS

It is seen, then, that if the rate of evaporation can be reduced, the filaments can be operated at a higher temperature and, other things being equal, at a higher efficiency. Inert gases introduced into the bulb increase the pressure bearing upon the filament, and the practicable operating temperature can thereby be increased. However, with lamps where the filaments of ordinary size were mounted in the regular way, the loss due to heat being conducted away by the gas is great enough to more than offset the advantages obtained by operating the filament at a higher temperature. The development of the helically coiled tungsten filament permitted mounting in a small space near the center of the bulb, and the percentage loss through the gas was greatly reduced, with the result that these MAZDA C lamps became at once commercially practical in the higher wattages.

## LIFE DATA

The performance which a group of lamps may be expected to give in service varies with the character of the service and the method of installation. A group of lamps which under the tests prescribed in the standard specifications may be expected to have an average life of 1000 hours could not be expected to give a similar performance under unsatisfactory service conditions.

It is expected that where the regulation of the circuit voltage or current is good, and where the average value of the voltage or current while the lamps are burning is the same as that of the lamp label, a performance of approximately that given in the following table for the various lamps may be expected.

| Hours Burned | 0 | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 |
|---|---|---|---|---|---|---|---|---|---|---|
| Number lamps remaining | 100 | 97 | 94 | 89 | 77 | 60 | 39 | 17 | 3 | 0 |

The above statement includes the necessity of proper installation as MAZDA lamps cannot be expected to give their full rated life unless the service is as good as that given above and the lamps protected from excessive vibration or excessive handling. Lamps when fitted with reflectors or enclosed in housings of any kind can only be expected to give full average service life when these reflectors, enclosing mediums or housings are properly designed so as not to overheat any part of the lamp.

In considering average service life it must be remembered that although some lamps show a shorter life than the average, others will show a life correspondingly longer.

To illustrate this further the above figures may be given as representing the number of lamps out of an original lot of 100 60-watt MAZDA B lamps which might be expected to be burning at the end of various periods of service as indicated above. It should be remembered in considering this table that the data are typical of 60-watt MAZDA B lamps of the standard voltage range. Other sizes and types of lamps have different characteristics; small lamps, for example, having a larger number of early burnouts than some of the larger sizes.

The table, therefore, will serve to illustrate only the more usual standard types of multiple lamps and is not necessarily representative of lamps for stereopticon service, locomotive headlight service, street railway service, flood lighting service, round bulb lamps, tubular lamps, or the MAZDA C lamps of any of the various sizes.

In the lot of 100 lamps represented 40 lamps failed before the end of the rated life period, while 60 lamps burned beyond. The average life of all lamps, however, is slightly in excess of 1000 hours.

The rated average total life of most of the usual sizes of large MAZDA lamps listed on the regular schedules is 1000 hours. Following are some of the exceptions:

MAZDA B lamps for ornamental lighting service: round bulb lamps, 750 hours; 25-watt T-10 bulb lamps, 500 hours; 40-watt T-8 bulb lamps, 600 hours.

MAZDA B lamps for sign lighting service, 1500 hours.

MAZDA B lamps for electric street railway service, 1500 hours.

MAZDA C lamps for street lighting service, 1350 hours.

MAZDA C lamps for locomotive headlight service, 30–34 volts, 500 hours.

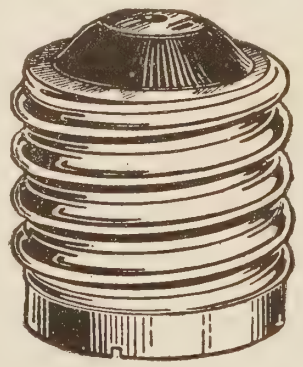
MAZDA Daylight lamps, 700 hours.

MAZDA C lamps for stereopticon and motion picture projection service, 100 hours. MAZDA C lamps for floodlighting service, 800 hours.

VOLTAGE RANGE is the total range of voltage for which lamps may be ordered. Lamps are manufactured for each individual voltage included within this range. Some lamps, for operation in connection with standardized equipment having a limited voltage variation, are manufactured at one voltage rating only. Such lamps are designed to meet the average voltage conditions of the intended service and are labeled according to the voltage limits which have been found characteristic of that service. Thus lamps for standard lighting service are listed under the voltage range of "110 to 125 volts" and lamps for any individual voltage between these limits may be ordered, while lamps for country home lighting service are manufactured at one voltage and labeled at "28–32 volts" which indicates the limited variation of voltage of such circuits.

BASES are designated by a name, such as "Medium Screw," "Mogul Screw," etc., which indicates the type of socket in which the base will fit. Bases on lamps having bulbs with large necks, may be fitted with an insulated shell known as a skirt. Such bases are designated as skirted.

Medium Screw Base (Unskirted)



Mogul Screw Base (Unskirted)

BULB. The diameter of a bulb is expressed in eighths of an inch and is always used in conjunction with the letter designating the type of bulb, such as the S-19; "S" indicating that the bulb is a straight-side bulb and "19" indicating that the bulb is 19/8ths of an inch in diameter; or the G-25 bulb, the "G" indicating a round (globular) bulb and the "25" indicating that the bulb is 25/8ths of an inch in diameter. The bulb designation "PS" indicates "pear shape." These bulbs are generally used for MAZDA C lamps. The letter "T" indicates a tubular bulb.

As the heat carried away by the gas from a thin filament of low wattage is proportionately greater than from a thick filament of high wattage, there is, therefore, a wattage below which MAZDA B lamps become more efficient

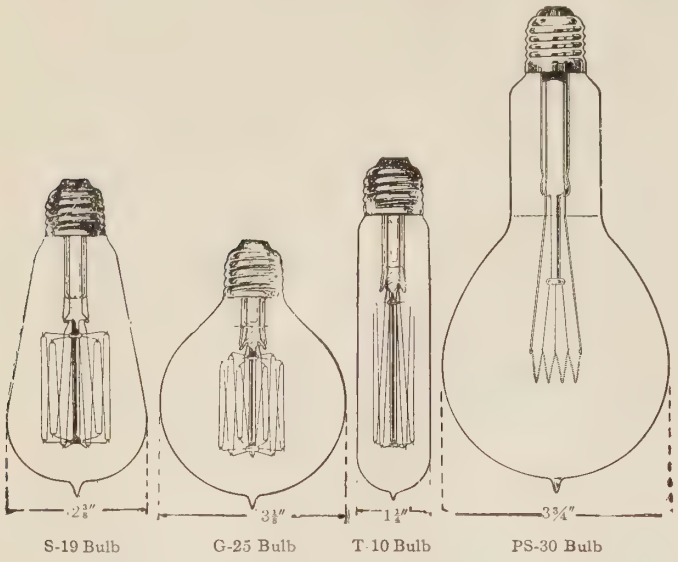



Fig. 8

BULB CLASSIFICATION (Lamps Illustrated ¼ Scale)

than MAZDA C lamps of the same voltage and rated life. At present MAZDA C lamps are not manufactured below 50 watts in 110 to 125 volts for the reason that they would not be as efficient as the MAZDA B lamps under 50 watts now made.

LIGHT CENTER LENGTH is the distance from the center of the filament to the end contact point of the screw base.

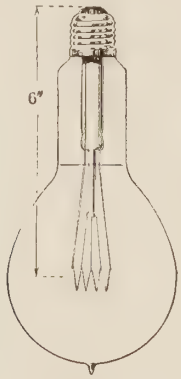



Fig. 4

MAZDA C LAMP—6-IN. LIGHT CENTER LENGTH

## THE EFFECT OF LAMP VOLTAGE UPON LIGHTING SERVICE

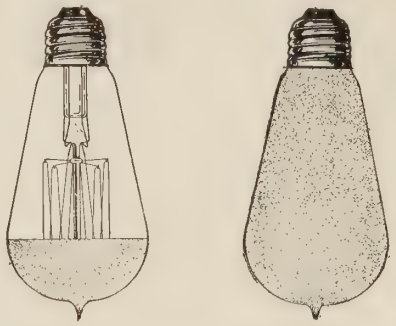
Lamp users will occasionally complain of "dim lights." The user generally assumes that dim lights are an indication that he is not getting the proper service, but this assumption may not be justified by the facts.

It may be that he has tried to use an inferior grade of lamp in which case the reason for complaint will not be hard to find, or more likely, he may be using lamps of wrong voltage for his circuit. Sometimes this is due to a mistake or to carelessness, but more often it is due to a lack of knowledge as to the actual voltage at the sockets in which the lamps are to be operated.

In some cases the user will advise that the lights are all right until he turns on additional lights and then they grow dim. This indicates that its circuits are overloaded and steps should be taken to remedy this condition.

It is advisable that the labeled voltage on a lamp be the same or at least no higher than the actual average voltage at the lamp socket in which the lamp is used.

FROSTED LAMPS have the outside surface of the bulb treated by a sand-blast or acid process to soften the light and make it less glaring. "All frosted"



Bowl Frosted Lamp  All Frosted Lamp

lamps are those which have the bulb entirely frosted. "Bowl frosted" lamps are those which have the bulb frosted from the tip to the maximum diameter of the bulb.

ALTHOUGH no attempt has been made in this catalog to cover our department which handles Electric Lighting Fixtures, it should be remembered that we specialize on the installation of electric lighting equipment for Residences, Public Buildings, Hospitals, Churches, Theatres, etc.

The services of our Electric Illuminating Engineers and Fixture Designers are always at the command of those who desire assistance of a thoroughly competent character.

Those interested in lighting facilities for the home will find it extremely interesting to visit our Fixture Studios. Our showing of attractive designs includes types appropriate to any scheme of interior treatment.

## VARIATION OF CANDLE-POWER WITH VOLTAGE FOR MAZDA LAMPS

A MAZDA lamp gives its rated candle-power only when operated on a circuit of a voltage equal to the rated voltage of the lamp. If the rated voltage is less than the circuit voltage, the candle-power will be increased and vice versa. The following table shows the relations between circuit voltage, lamp voltage and candle-power produced.

To illustrate the use of the table: Suppose a customer to have a circuit of voltage 112. If he burns 108-volt MAZDA lamps on this circuit then candle-power will be 113.6 per cent. of their normal rating (found in the column headed 112 and in the row opposite 108). Similarly, if the customer burns 116-volt MAZDA lamps, their candle-power will be 88.4 per cent. of normal.

| Voltage of Lamp | Voltage of Circuit | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 |
| 105 | 100.0 | 103.4 | 106.9 | 110.4 | 114.0 | 117.6 | 121.4 | 125.2 | 129.1 | 133.1 | 137.2 | | | | | | | | | | |
| 106 | 96.7 | 100.0 | 103.4 | 106.8 | 110.3 | 113.9 | 117.5 | 121.2 | 125.0 | 128.8 | 132.8 | 136.9 | | | | | | | | | |
| 107 | 93.6 | 96.8 | 100.0 | 103.4 | 106.7 | 110.2 | 113.7 | 117.3 | 121.0 | 124.7 | 128.5 | 132.5 | 136.5 | | | | | | | | |
| 108 | 90.5 | 93.6 | 96.8 | 100.0 | 103.3 | 106.7 | 110.1 | 113.6 | 117.1 | 120.8 | 124.5 | 128.2 | 132.2 | 136.1 | | | | | | | |
| 109 | 87.6 | 90.6 | 93.7 | 96.8 | 100.0 | 103.3 | 106.6 | 110.0 | 113.5 | 117.0 | 120.6 | 124.2 | 128.0 | 131.8 | 135.7 | | | | | | |
| 110 | 84.9 | 87.8 | 90.7 | 93.8 | 96.8 | 100.0 | 103.3 | 106.6 | 109.9 | 113.3 | 116.8 | 120.4 | 124.0 | 127.7 | 131.5 | 135.4 | | | | | |
| 111 | 82.2 | 85.0 | 87.9 | 90.8 | 93.8 | 96.9 | 100.0 | 103.2 | 106.5 | 109.8 | 113.2 | 116.6 | 120.2 | 123.8 | 127.4 | 131.2 | 135.0 | | | | |
| 112 | 79.6 | 82.3 | 85.1 | 88.0 | 90.9 | 93.9 | 96.9 | 100.0 | 103.2 | 106.4 | 109.7 | 113.1 | 116.5 | 120.0 | 123.6 | 127.2 | 130.9 | 134.7 | | | |
| 113 | 77.1 | 79.7 | 82.5 | 85.2 | 88.1 | 91.0 | 93.9 | 96.9 | 100.0 | 103.2 | 106.4 | 109.6 | 113.0 | 116.3 | 119.8 | 123.3 | 126.9 | 130.6 | 134.3 | | |
| 114 | 74.7 | 77.3 | 79.9 | 82.7 | 85.4 | 88.2 | 91.0 | 94.0 | 97.0 | 100.0 | 103.1 | 106.3 | 109.5 | 112.9 | 116.2 | 119.6 | 123.1 | 126.7 | 130.3 | 134.0 | |
| 115 | 72.4 | 74.9 | 77.5 | 80.1 | 82.8 | 85.5 | 88.3 | 91.1 | 94.0 | 97.0 | 100.0 | 103.1 | 106.3 | 109.5 | 112.7 | 116.1 | 119.5 | 122.9 | 126.4 | 130.0 | 133.7 |
| 116 | ..... | 72.6 | 75.1 | 77.6 | 80.2 | 82.9 | 85.6 | 88.4 | 91.2 | 94.1 | 97.0 | 100.0 | 103.1 | 106.2 | 109.4 | 112.6 | 115.9 | 119.3 | 122.7 | 126.2 | 129.7 |
| 117 | ..... | ..... | 72.8 | 75.3 | 77.8 | 80.4 | 83.0 | 85.7 | 88.5 | 91.3 | 94.1 | 97.0 | 100.0 | 103.1 | 106.2 | 109.3 | 112.5 | 115.8 | 119.1 | 122.5 | 126.0 |
| 118 | ..... | ..... | ..... | 73.0 | 75.5 | 78.0 | 80.6 | 83.2 | 85.8 | 88.5 | 91.3 | 94.2 | 97.1 | 100.0 | 103.0 | 106.1 | 109.2 | 112.4 | 115.6 | 118.9 | 122.3 |
| 119 | ..... | ..... | ..... | ..... | 73.2 | 75.7 | 78.1 | 80.7 | 83.3 | 85.9 | 88.6 | 91.4 | 94.2 | 97.1 | 100.0 | 103.0 | 106.0 | 109.1 | 112.3 | 115.5 | 118.7 |
| 120 | ..... | ..... | ..... | ..... | ..... | 73.4 | 75.9 | 78.3 | 80.8 | 83.4 | 86.0 | 88.7 | 91.5 | 94.3 | 97.1 | 100.0 | 103.0 | 106.0 | 109.0 | 112.2 | 115.3 |
| 121 | ..... | ..... | ..... | ..... | ..... | ..... | 73.6 | 76.0 | 78.5 | 81.0 | 83.5 | 86.1 | 88.8 | 91.5 | 94.3 | 97.1 | 100.0 | 103.0 | 105.9 | 109.0 | 112.0 |
| 122 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 73.8 | 76.2 | 78.7 | 81.2 | 83.7 | 86.3 | 88.9 | 91.6 | 94.4 | 97.1 | 100.0 | 102.9 | 105.9 | 108.9 |
| 123 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 74.0 | 76.4 | 78.8 | 81.3 | 83.8 | 86.4 | 89.0 | 91.7 | 94.4 | 97.2 | 100.0 | 102.9 | 105.9 |
| 124 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 74.2 | 76.6 | 79.0 | 81.4 | 83.9 | 86.5 | 89.1 | 91.7 | 94.5 | 97.2 | 100.0 | 102.9 |
| 125 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 74.4 | 76.7 | 79.1 | 81.6 | 84.0 | 86.6 | 89.2 | 91.8 | 94.5 | 97.2 | 100.0 |

## VARIATION OF WATTS WITH VOLTAGE FOR MAZDA LAMPS

A MAZDA lamp consumes its rated watts only when operated on a circuit of a voltage equal to the rated voltage of the lamp. If the rated lamp voltage is less than the circuit voltage, the watts will be increased and vice versa. The following table shows the relations between circuit voltage, lamp voltage, and watts consumed.

To illustrate the use of the table: Suppose a customer to have a circuit of voltage 112. If he burns 108-volt MAZDA lamps on this circuit their wattage will be 105.9 per cent. of their normal rating (found in the column headed 112 and in the row opposite 108). Similarly if the customer burns 116-volt MAZDA lamps, their watts will be 94.6 per cent. of normal.

| Voltage of Lamp | Voltage of Circuit | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 |
| 105 | 100.0 | 101.5 | 103.0 | 104.6 | 106.1 | 107.6 | 109.2 | 110.7 | 112.3 | 113.9 | 115.5 | | | | | | | | | | |
| 106 | 98.5 | 100.0 | 101.5 | 103.0 | 104.5 | 106.0 | 107.6 | 109.1 | 110.6 | 112.2 | 113.7 | 115.3 | | | | | | | | | |
| 107 | 97.1 | 98.5 | 100.0 | 101.5 | 103.0 | 104.5 | 106.0 | 107.5 | 109.0 | 110.5 | 112.1 | 113.6 | 115.2 | | | | | | | | |
| 108 | 95.7 | 97.1 | 98.5 | 100.0 | 101.5 | 103.0 | 104.4 | 105.9 | 107.4 | 108.9 | 110.4 | 112.0 | 113.5 | 115.0 | | | | | | | |
| 109 | 94.3 | 95.7 | 97.1 | 98.6 | 100.0 | 101.5 | 102.9 | 104.4 | 105.8 | 107 3 | 108.8 | 110.3 | 111.8 | 113.4 | 114.9 | | | | | | |
| 110 | 92.9 | 94.3 | 95.7 | 97.1 | 98.6 | 100.0 | 101.5 | 102.9 | 104.4 | 105.8 | 107.3 | 108.8 | 110.2 | 111.7 | 113.2 | 114.8 | | | | | |
| 111 | 91.6 | 93.0 | 94.4 | 95.8 | 97.2 | 98.6 | 100.0 | 101.4 | 102.9 | 104.3 | 105.7 | 107.2 | 108.7 | 110.1 | 111.6 | 113.1 | 114.7 | | | | |
| 112 | 90.3 | 91.7 | 93.0 | 94.4 | 95.8 | 97.2 | 98.6 | 100.0 | 101.4 | 102.9 | 104.3 | 105.7 | 107.2 | 108.6 | 110.0 | 111.5 | 113.0 | 114.5 | | | |
| 113 | 89.0 | 90.4 | 91.7 | 93.1 | 94.4 | 95.8 | 97.2 | 98.6 | 100.0 | 101.4 | 102.8 | 104.2 | 105.7 | 107.1 | 108.5 | 109.9 | 111.4 | 112.9 | 114.3 | | |
| 114 | 87.8 | 89.1 | 90.5 | 91.8 | 93.2 | 94.5 | 95.9 | 97.2 | 98.6 | 100.0 | 101.4 | 102.8 | 104.2 | 105.6 | 107.0 | 108.4 | 109.8 | 111.3 | 112.8 | 114.2 | |
| 115 | 86.6 | 87.9 | 89.2 | 90.5 | 91.8 | 93.2 | 94.5 | 95.9 | 97.3 | 98.6 | 100.0 | 101.4 | 102.8 | 104.2 | 105.6 | 107.0 | 108.4 | 109.8 | 111.2 | 112.7 | 114.1 |
| 116 | ..... | 86.7 | 88.0 | 89.3 | 90.6 | 91.9 | 93.3 | 94.6 | 96.0 | 97.3 | 98.6 | 100.0 | 101.4 | 102.7 | 104.1 | 105.5 | 106.9 | 108.3 | 109.7 | 111.1 | 112.5 |
| 117 | ..... | ..... | 86.8 | 88.1 | 89.4 | 90.7 | 92.0 | 93.3 | 94.6 | 96.0 | 97.3 | 98.6 | 100.0 | 101.4 | 102.7 | 104.1 | 105.5 | 106.8 | 108.2 | 109.6 | 111.0 |
| 118 | ..... | ..... | ..... | 86.9 | 88.2 | 89.5 | 90.8 | 92.1 | 93.4 | 94.7 | 96.1 | 97.4 | 98.7 | 100.0 | 101.4 | 102.7 | 104.1 | 105.4 | 106.8 | 108.2 | 109.5 |
| 119 | ..... | ..... | ..... | ..... | 87.0 | 88.3 | 89.6 | 90.8 | 92.1 | 93.4 | 94.7 | 96.1 | 97.4 | 98.7 | 100.0 | 101.4 | 102.7 | 104.0 | 105.4 | 106.7 | 108.1 |
| 120 | ..... | ..... | ..... | ..... | ..... | 87.1 | 88.4 | 89.7 | 90.9 | 92.2 | 93.5 | 94.8 | 96.1 | 97.4 | 98.7 | 100.0 | 101.4 | 102.7 | 103.9 | 105.3 | 106.7 |
| 121 | ..... | ..... | ..... | ..... | ..... | ..... | 87.2 | 88.5 | 89.7 | 91.0 | 92.2 | 93.5 | 94.8 | 96.1 | 97.4 | 98.7 | 100.0 | 101.3 | 102.7 | 103.9 | 105.3 |
| 122 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 87.3 | 88.6 | 89.8 | 91.1 | 92.3 | 93.6 | 94.9 | 96.1 | 97.4 | 98.7 | 100.0 | 101.3 | 102.6 | 103.9 |
| 123 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 87.4 | 88.7 | 89.9 | 91.2 | 92.4 | 93.7 | 94.9 | 96.2 | 97.5 | 98.7 | 100.0 | 101.3 | 102.6 |
| 124 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 87.5 | 88.8 | 90.0 | 91.3 | 92.5 | 93.7 | 94.9 | 96.2 | 97.5 | 98.7 | 100.0 | 101.3 |
| 125 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 87.6 | 88.9 | 90.1 | 91.3 | 92.5 | 93.7 | 95.0 | 96.2 | 97.5 | 98.7 | 100.0 |

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